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INTRODUCTION.

THE readers of a new Periodical are fairly entitled to receive at the hands of its projectors, not only a statement of the grounds upon which it has been established, but also some exposition of its intended scope and objects.

The word "some" is here designedly used, for it is not improbable that a work of this description, professing to keep pace with the advancing intelligence of mankind, and even, should opportunities present themselves, to serve as a pioneer of progress, may in the course of time become so modified as materially to change its character. And as we are fortunately not trammelled by those conditions which in the commercial world frequently place limits upon a project when it is first set on foot, we shall reserve to ourselves the right of introducing amendments, or of supplying deficiencies as our work proceeds, adopting the old proverb that "Times change, and with them we shall change also." As this may appear a somewhat vague announcement of our plans, we will shortly conduct our readers to a standpoint from whence they may obtain a survey of the field of our intended labours, and in the meantime we would invite them to follow us in a few reflections which have been the cause of our venturing, at this particular period, into the ranks of literature.

How does it happen that from the earliest ages of the historic record, Art has been a favoured offspring of the human intellect, the spoiled child of man, whilst to Science he has been but a sorry stepfather? In his rudest stages, he wooed her favour, painting his own skin if he could paint nought else, and in the palmy days of his early civilization he raised her upon a pedestal from which she never descended, although in the dark ages that followed, her figure was for the time obscured. Not so with Science. Her youthful steps have always been watched with jealousy and suspicion, and instead of guidance and support, every obstacle has been thrown in her path, her grandest revelations being

frequently held up to scorn and obloquy, and twisted and tortured until they were made to appear the teachings of the Evil One.

We have but to place side by side the artist whose employment has been to copy the works of nature, and the student who has enunciated her laws; or the modeller in stone, and the teacher of those truths which even stones reveal; and what a contrast do they afford! The labours of the one have been rewarded with a wreath of laurel, whilst a crown of thorns has ever fallen to the other's lot.

How is this phenomenon to be explained? Can it be—and we make the inquiry with due appreciation of her elevating tendencies—can it be that the ways of Art are elastic and accommodating, and that without distinction of sect or creed, she has always been the servant of Theology, doing duty alike for Hebrew and Greek, Mahommedan and Christian, whilst Science has held aloof from all these denominations and has walked only with the religion taught by nature? Or is it that the truths of Science can only be understood and appreciated by the cultivated intellect, whilst the beauties of Art impress themselves upon the unaided sense?

We refrain from pressing the inquiry further, lest it be imagined that we would seek to elevate our mistress at the expense of a sister, or that we are assuming a petulant tone and an attitude of hostility towards one with whom we desire to walk hand in hand, and to whom also our co-operation is daily becoming more indispensable.

Leaving our readers, then, to work out the problem for themselves as regards the past, we proceed to inquire whether the existing state of things holds out a more hopeful prospect to Science and her votaries; and here the replies are sufficiently plain and satisfactory.

A certain amount of scientific knowledge is now absolutely necessary to men of all ranks, and forms an essential element in a liberal education. The influence of scientific discovery is becoming daily more powerful, and is making itself felt in almost every vocation of life. Science not only succours the wounded on the battle-field, but without her powerful aid, bravery is of no avail in the General, nor in the ranks. The loud and fluent tongue of the pleader may seek to persuade, but without the unobtrusive evidence of the man of science it fails to convince. The tiller of the soil may labour unremittingly with his hands, and waste the sweat of his brow, but his neighbour looks on, smiling, and lets the steam-engine perform his work more speedily and at a smaller cost. And so it is everywhere,—in the factory or mine, in the university or schoolroom, in the world of pleasure as in the world of pain.

It is true that, for the moment, a few theologians and politicians are inclined to underrate her influence, and even in some instances to

close their ears to her teachings; but these are exceptional cases, and those who "waste their philosophic pains" in thus endeavouring to stem the tide of progress, will one day find themselves drifting alone down the current with which they might have sailed in the company of their fellow-travellers on the way to Truth.

Scientific knowledge is now eagerly sought, and its possessors are respected. Here and there a few impetuous workers or thinkers give utterance to tenets which shock the temperate and cautious, and lead the pious to believe that another golden calf is about to be set up for worship; but these are the exceptions, and compared with Theology and Politics, Science has but few extremists. As, however, her devotees are rather men of thought and action than of wordy eloquence, they are often less appreciated than the fruits of their labours, and thus it happens that the astute politician or the talented historian may edge his way on to the Treasury Bench, or arrive at the dignity of a Peerage, and the eloquent Theologian may succeed in reaping a Bishopric, whereas the able man of science whose labours have changed the destiny of nations, or who has given a new direction or a fresh impulse to the course of civilization, must content himself with a Knighthood, or declining that, must rest satisfied with the honourable letters affixed to his name by his fellow-labourers, and leave it to posterity to raise an enduring monument to his memory.

Still, as we have said, Science is beginning to exercise a potent influence in every circle of society, and not only does she reckon amongst her followers multitudes of the labouring classes (so many, indeed, that it has been found necessary to organize a special department and machinery in the State to aid them in the pursuit of this species of knowledge), but even lords and statesmen who had previously bestowed all their favours upon the nurseries of literature, are now beginning to cast tender glances upon Schools of Science, and other similar institutions. The discoveries of unwearying investigators, too, and the explorations of bold adventurers on the earth or sea, or in the air, are no longer published in ponderous tomes and modest "brochures," but find a rapid utterance in special periodicals, and even in the flying sheets of the daily press,—those great organs of public opinion without which no man can live the life of the nineteenth century.

Thus much by way of preface to the consideration of the present state of Scientific knowledge; but if, from a theme so noble and inspiring, we have been able to derive so little eloquence, what words shall we find to plead our own cause? As we approach the subject, we feel as does the candidate for public suffrage, who comes before the constituency primed with eloquent appeals and telling periods,

but who, when he sees the crowd of curious upturned faces, concealing tongues ready to applaud, but equally prompt to hiss, finds that his labelled sentences are gone, and with them his courage to seek fresh ones.

Let us, then, be brief.

We have been told by men in every walk of life, that the time is come when Science may claim for herself a special organ; that not alone scientific readers, but those of every class, desire to approach the source from whence this species of knowledge is derived,—to learn in which direction the current flows, and how it is likely to affect their material interests or questions bearing upon their eternal happiness.

To supply such a want is a truly ambitious aim, and one which, we do not hesitate to confess, we should never have proposed to ourselves had we not been first assured of the co-operation of those whose powers alone are equal to its accomplishment.

With men illustrious in Science, ready to avail themselves of these pages as a medium of communication with the public, and to many of whom we acknowledge ourselves already indebted, both for friendly counsel and for active co-operation, we now set out, full of hope and confidence; and before giving place to those whose words will have much weight, and whose teachings cannot fail to exercise a beneficial influence, we invite our readers to advance a few paces with us, to an eminence from which we may be enabled to point out to them some of the more prominent farmsteads on the surrounding fields of Science, where the labourers are to-day busy sowing or reaping, enriching old, or winning new pastures.

This figurative remark naturally leads us to the consideration of one or two of the more prominent features in connection with the Science and practice of Agriculture as they are to-day presented to our notice; and, perhaps, no subject is more deserving of attention at our hands than the Drainage and Cultivation of land.

It is, probably, unknown to the large majority of our readers, that a legislative enactment was passed, a few years since, called the "Land Drainage Act," the object of which was to enable proprietors of arable and pasture land situated in valleys or level districts more effectually to drain such land by the acquisition of a convenient access to what are termed the arterial drains (the smaller streams and rivers); in fact, to give them what, in the railway world, would be called "running powers" for a drain through a neighbour's estate.

When they are informed that by improved drainage the rental of some kinds of land may be raised from 5*s.* or 6*s.* to 40*s.*, or even 50*s.* an acre, whilst the poorer soils are capable of being enhanced four-

fold, our readers will perceive this movement to be one of great practical importance. To do our English landowners and farmers justice, it would appear that they have always been willing to grant this accommodation to a neighbour, but, owing to the laws of entail and other conditions of society, this has been but a fleeting privilege, and should the obliging neighbour die, and be followed in the possession of his estate by one less accommodating, the outlet might at any moment be blocked up or otherwise intercepted, and then the owner of the drained land would have no power to cause it to be cleared or reconstructed.

Several previous attempts had been made to remedy this evil by legislative enactments, all of which proved futile; but under the new Act (which appears to have objectionable as well as advantageous features) a local Board may now be formed, having power to assess a rural district precisely as in the case of a "commission of sewers." The method by which it is intended to improve the drainage of land is by doing away with those mill-dams which interfere with the free current of an arterial drain, as well as through the utilization of others by which the flow is facilitated; by collecting and storing up surplus water, and preserving it for seasons of drought; and pumping stagnant water by mechanical power from low to high levels, and thence directing it into arterial drains. To attain these objects, it is requisite to secure the hearty co-operation of whole agricultural districts, and owners of land should not look to their own immediate interests alone, but should consider the welfare of their neighbours and posterity.

The promoters of such movements as these will find us ever ready to advocate their cause and give publicity to their reasonable suggestions.*

But good drainage alone is not a sufficient preparation of the soil for the reception of the parent seed; deep and constant furrowing are also requisite, and for this purpose steam is rapidly and advantageously superseding horse-power. The work is accomplished more efficiently and speedily, and there are descriptions of soil, and seasons when it would be absolutely ruinous to allow horses to tread the land whilst dragging the plough, whereas no obstacle whatever is opposed to steam traction. Indeed, the substitution of the latter for the former has, no doubt, frequently gained a season to the farmer, as his improved harvesting implements have saved him a valuable crop.

It is hardly needful to add, that with improved drainage and cultivation of the soil, the farmer secures more valuable produce. Light,

* Mr. J. Bailey Denton has been most active in bringing about improved drainage, and in procuring enactments for the purpose.

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scanty grain gives place to the full rich ear, and succulent grasses and clovers supplant the poorer kinds; in fact, the "conditions of existence" are altered, and the weed no longer finds a genial bed. The soil prepared, we next come to the seed; and here, too, the agriculturist has enlisted science in his cause. Two attempts are being made to increase the produce of cereals: one by the use of what is termed "pedigree seed;" that is, a seed derived from repeated selections of the finest ears—the original parent being an ear of great size—by artificial selection, in fact; the other by artificial fructification. Our limited space will not permit us to dwell upon either of these systems, which will probably be treated in detail hereafter by abler pens than ours; and we must refer to the farmer's last trouble—save and except the conversion of his harvest into gold, in which process he stands in need of other speculations than those of scientific men—we mean the saving of his produce, or, we might almost say, the conquest of the elements.

The improvements which are daily taking place, to enable him to expedite and cheapen his harvest operations, deserve, and will receive a special place with us. The reaping and mowing machines which have been some time in use in America are now approaching perfection in England, and the haymaking machine has already rescued many a crop that would otherwise have been sacrificed. A little more speed; a few more applications of scientific principles; and the farmer may defy or wield the weather as he already manipulates and utilizes the soil.

But whilst the agriculturist turns with disfavour from the time-honoured running stream, and, pronouncing water-wheels a nuisance, calls in the aid of the steam-engine to every portion of his rapidly-progressing work, a leading mechanician steps forward, and warns us of the necessity of economizing coal and of utilizing water-power, lest the supply of the former should become exhausted. In his opening address, the President of the British Association startled the world, and more especially the geological world, with the announcement, that should the consumption of coal increase at its present rate, two centuries only will be the duration of the supply from the North Country coal-field; and that, if no greater economy be exercised than at present, a hundred years will suffice to bring about this result.

Whatever may be the value of this speculation, its propounder has been led by the consideration of the subject to practical conclusions, perhaps not novel ones, but of great importance to the community, in regard to the present mode of employing this precious fuel. He has shown that improved machinery, a better arrangement of the fire-

grate, and an easy method of firing, would not only economize its consumption to an almost incredible degree, but that the inhabitants of cities would be spared the annoyance and inconvenience of a vitiated atmosphere. Even in our present fireplaces, he tells us, we consume five times as much coal as would be requisite in a properly constructed stove or improved open fireplaces.

As regards the substitution of stoves for firesides, we suspect that our countrymen would rather dispense with coal altogether and return to the days of wood and turf, than allow such an innovation; but, as we shall have occasion to show hereafter, striking improvements are being introduced into the construction of land and marine engines, which herald a constantly increasing economy in the consumption of coal.

It would appear, however, from the opinions expressed by experienced practical geologists, that it is difficult at present to estimate even the exact area of our English coal-beds, and it is believed that the fields now worked will yield a sufficient supply of fuel to last nearly a thousand years.*

Leaving this subject, we have now to observe that the exploration of one new field has already produced results almost as startling, and certainly not less useful than the speculations of Sir William Armstrong. In sinking a shaft at Middlesborough, for the purpose of obtaining a supply of fresh water, Messrs. Bolckow and Vaughan, the enterprising pioneers of the coal and iron trade in that district, were so fortunate as to discover at a depth of twelve hundred and six feet, in the Trias, or New Red Sandstone formation, a deposit of rock salt, which, in August last, had been penetrated to the depth of nearly one hundred feet, without its lowest limit having been reached; and the brine, which was found to contain ninety-six per cent. of chloride of sodium, has been pronounced by an experienced chemist to be purer than that of Cheshire.

It is almost impossible for persons unacquainted with the mineral and manufacturing districts of Northumberland to form any conception of the importance of this discovery.

Hitherto, the soda manufacture of the Tyne has been entirely dependent for its supply of salt (from which the various preparations of soda are manufactured) upon the brine-springs of Cheshire and Worcestershire, and from these two counties at least one hundred thousand tons of salt have been conveyed annually, at a cost, in some cases, far exceeding the value at the works, of the mineral itself. Should the Cleveland salt-beds prove productive, the Newcastle soda

* For further information on this topic, we refer our readers to an article in the present number, on the "Coal Resources of Great Britain," by Mr. E. Hull.

makers will, of course, be greatly benefited, and will compete more successfully than they do at present with the Lancashire manufacturers for the supply of all the western markets.

As to the fortunate ironmasters, they will not only have found an unexpected mine of wealth in the salt-beds, but in the evaporation of the brine, they will be enabled to utilize the waste heat from their puddling and blast furnaces, as well as from their coke-ovens; thus adding profit to profit, and carrying out in an unexpected manner the economical principles recommended by the President of the British Association.

Closely allied to the question of Coal, is that of Petroleum—a natural product which is likely to exercise an important influence upon civilization. This hydro-carbon, some forms of which have long been known in India, has recently been found to exude from certain wells or springs in Pennsylvania and Canada. It is supposed to arise from the destructive distillation of a mineral bitumen beneath the surface, and on reaching the hand of man, it is subjected a second time to the distilling process, when it yields three distinct substances of considerable value. The first is a spirit, which is employed as a cheap substitute for turpentine; the second, a burning oil of great brilliancy, capable of being used in lamps of an almost nominal value, and itself procurable at an average price not exceeding half that of rape-oil;* and lastly, a kind of grease which is employed for lubricating coarse machinery. The importation of this substance (chiefly in its distilled form) is increasing rapidly, and may be reckoned by millions of gallons, and almost the only thing requisite to enable it to rank amongst our leading commercial staples, is an inexpensive air-tight cask, in which it may be stored, so as to obviate the enormous leakage which often causes it to be a ruinous venture to importers and dealers.

These are but two or three of the interesting results or applications of that geological knowledge, the development of which must necessarily occupy a prominent place in our pages; and being of a practical character, we have selected them for comment, in preference to those which bear upon the principles of the science itself, such as the Origin of Rocks, Earthquakes,† the Palæontological Evidences as to the Antiquity of the Human Race, and many other subjects which are now engaging the attention of scientific men.

Before quitting *terra firma* to follow the researches of Science into space, we must direct our attention for a few moments to the work of

* The wholesale price of the finest Petroleum Oil is now (November) one shilling and ninepence per gallon; of Rape or Colza Oil, three shillings and eightpence per gallon.

† On this subject, an article will be found in the present number, by Mr. Mallett.

Geographical Exploration, a subject of great interest in all literary, scientific, and political circles.

A new era is dawning upon the profession of the traveller, and those attributes which found their embodiment in the fictitious but far-famed German Baron Münchausen, are fast giving place to scrupulous care and accuracy in the description of places, and great modesty in the narrative of personal adventures.

This change is due in part to the general diffusion of knowledge amongst the masses, which enables men more readily to detect error and exaggeration; partly to the progress of the photographic art,* which is incapable of misrepresentation, and in a large measure to that wholesome competition amongst travellers themselves, which soon leads to the contradiction or verification of strange and novel discoveries. Amongst those who have earned for themselves a reputation for bravery and endurance, and who at the same time set an example of the virtue of modesty in the traveller, are the discoverers of the Source of the Nile, and the explorers of Central Australia.

It would be impossible for us even to refer to the adventures of Speke and Grant on their journey from Zanzibar to Lake Nyanza, where the source of the Nile was discovered, and thence down the great river into civilized Africa. Their discoveries have been aptly compared by Mr. Crawfurd to those of Columbus, and the practical benefits which are likely to follow them through the introduction or improved cultivation of useful products of the soil, and the civilization of barbarous peoples, will, in this case as in that of Burke and Wills, recompense the world for the loss of many of its best sons in the service of exploration.

But whilst we give a meed of praise to these adventurous travellers, we consider it right also to inquire whether or not the governments of civilized Europe, and more especially our own legislators, are bearing their share of the burden, and extending a fair amount of support to those who risk their lives in the cause of civilization.

This question will be answered best by a reference to what is passing in those regions of Western Equatorial Africa which have so long been the seat of the slave-trade and of human sacrifices. His Majesty the King of Dahomey must begin to have an elevated notion of his own importance, as traveller after traveller, and one representative after another from the Courts of Europe, solicits his permission to visit him, and to remonstrate with him upon the errors

* No traveller can plead the excuse that photography is difficult of application, after what was accomplished by Professor Piazzi Smyth, at an altitude of 10,700 ft. above the sea level, during the Teneriffe expedition.

of his ways; and if these numerous visits have brought about no other improvement in the untutored mind of the sable despot, they have at least imparted to it diplomatic powers which would reflect credit upon any European autocrat. It is quite amusing to observe how he "cuts his cloth according to his pattern," flattering one traveller and slighting another, as the force of circumstances may direct.

Amidst the conflicting accounts received from Wilmot, Burton, Craft, and Gerard,* it is difficult to form a correct estimate of his character, but a comparison of the narratives of all these travellers, with that of Speke and Grant concerning the kings on the route taken by them, leaves but little doubt that, in common with that of most of these sable monarchs, his every-day rule is characterized by cruelty, superstition, avarice, and almost every conceivable form of licentiousness and oppression.

Why, then, are our statesmen so delicate in their interference or non-interference in the internal affairs of Dahomey? Oude was swallowed at a single mouthful, as an inconvenient neighbour in India; and Japan and China were pierced to the very centre to compel their peoples to listen to the voice of European civilization and open their ports to western trade. Why are our French allies so characteristically polite towards the slave-dealing King of Dahomey, whilst the rulers of Mexico are made to flee before their victorious arms, to avenge the injured honour of France, and to compel redress for the private grievances of her subjects? The reply is a simple one, and is furnished to us by our neighbours themselves—"*Le jeu ne vaut pas la chandelle.*"

Ministers may bestow a few hundreds of pounds upon such a cause, and may compensate for the small expenditure of funds by a lavish supply of letters of introduction; but is it worth while, they ask themselves, to make war for an idea—the suppression of the slave-trade—when the material result will be an improved supply of ivory or palm oil, or a small addition to our importation of cotton wool?

Were the supply of tea (or the demand for opium) likely to be affected, or if some great semi-civilized nation were to be coerced into buying cotton-cloths, then no sacrifice of men or money would be considered too great until the desired end was attained; but, in the meanwhile, Zoological and Geographical Societies and private individuals are compelled to support enterprising adventurers in their efforts to reclaim the waste places of the earth, whilst statesmen hold aloof until the bold pioneer has broken a gap in the hedge, perhaps at the

* From whom an interesting communication will be found in the present number.

cost of his life, and then they follow slowly and cautiously to plant the national standard.

Some day it may be found politic for Governments to take the initiative in such matters, and meanwhile exploring expeditions fitted out by Societies, and the attempts of isolated travellers, such as those who have penetrated into Africa, Australia, and South America, will find a prominent and well-merited place in these pages, and we shall always be ready to afford them our best aid in their efforts to contribute to our geographical knowledge.

As we pass upwards from earth to air, we still find courageous adventurers at work in the cause of Science. Here, too, they are steadily occupied in the task of tracing the operation of Nature's laws under what we consider abnormal conditions, and, by positive evidence, supplanting the calculations of experimental meteorologists whose feet have never left the solid ground.

On these subjects our great atmospheric explorer, Mr. Glaisher, has accumulated a fund of trustworthy information. He has shown that, with an increased altitude, we have not always proportionally diminished temperature, but that the latter is sometimes abnormal to the extent of from one to twenty degrees, during the ascent; that the most rapid decline takes place after leaving the earth, and that the rate of diminution is less in proportion to the increased altitude. The laws of hygrometric variation, too, he has studied and defined more clearly; and, not content with purely physical observations, he has contributed psychological facts of great interest. It would appear from his experience that at great heights every sense becomes more active, and that impressions there formed are more firmly fixed upon the mind than those received below. No doubt the novelty of the situation has a great deal to do with this phenomenon, but altered physical conditions probably exercise a powerful influence upon the nervous system and the mind.

For the benefit of those who brand men of science as infidels, and rail at the "intellectual pride" which, they say, causes them to substitute their own knowledge for the truths of religion, we will quote a few sentences from a discourse of Mr. Glaisher, on the religious influence exercised upon him by his aërial flights, and we hope they may have the effect of removing the false impression as to a want of reverence in scientific men:—"I have experienced the sense of awe and sublimity myself, and have heard it on all sides from aëronauts, who have both written and said the same. For my own part, I am an overwrought, hard-working man, used to making observations and eliminating results, in no way given to be poetical, and devoted to the

immediate interest of my pursuit, and yet this feeling has overcome me in all its power. I believe it to be the intellectual yearning after the knowledge of the Creator, and an involuntary faith acknowledging the immortality of the soul."

In Meteorology there are many new features which might afford themes for passing thoughts. The students of Physical Science are directing their attention to the consideration of the nature of fogs upon our coast, and an eminent observer* has discovered that they are either confined to a very limited area, or reach from one to two hundred miles, whilst none have been observed intermediate between these in extent. Nothing definite is known as to their immediate cause. The observations of Admiral Fitzroy upon the course of wind-currents might further detain us, but we cannot tarry any longer in the atmosphere, and must pass, if but for an instant, beyond its limits into the infinite universe, in order to direct attention to one or two features in Astronomical Science indicative of the character of our future inquiries.

No subject has of late attracted more attention than the application of Photography and of Spectrum Analysis to the examination of the heavenly bodies. The labours of Mr. Warren de la Rue in the first-named subject are too well known to require comment; and although the latter application of physical knowledge is yet in its infancy, it has already made us acquainted with some of the constituent materials of the sun, moon, and a few of the fixed stars.

But if the advances made in Chemistry and Physics have placed the heavenly bodies within the reach of experimental and analytical treatment, pure Inductive Science is not on that account the less active in the heavens. Only recently it has been busy in our solar system, upon whose subordinate members new light is likely to be thrown by a careful observation of the so-called "spots" upon the sun's surface. Here, too, the photographic art has been enlisted to perpetuate and confirm the results of astronomical observation. An able astronomer† has arrived at the conclusion, that there is a connection between the "behaviour" of the sun's spots and the configuration and relative position of the planets, and has photographed those "spots," for the purposes of comparison and inference.

Such experiments as these, and all other matters relating to the progress of Astronomy, as well as to the improvement in the fabrication of philosophical instruments already in use, or the introduction of new ones, will meet with a due share of our attention; and it is only necessary to refer to the recent introduction of Time-balls, and Time-

* Dr. Gladstone. † Mr. Stewart, of Kew.

guns, and to their employment in such places as London, Edinburgh, Liverpool, Newcastle, &c., to show how practical is the value of this branch of Science, and how immediately it affects the comfort and safety of the community.*

And having now descended once more to the earth's surface and directed our thoughts to man and his surroundings, it is necessary that we should devote a few pages to the consideration of those subjects which are more immediately connected with his interests, and which affect his own character and condition; and with this view we shall cast a glance at the Natural History Sciences.

One of the most interesting, and certainly the most practically useful subjects to which we can direct attention, is the transport and acclimatization of plants and animals.

We have but to refer to the transplantation of the Quinine-yielding Chinchona-tree from South America to India, and its successful cultivation there; to the introduction of British fruits into the Australian colonies; and to the effort, hitherto but partially successful, to transport British salmon into those colonies for breeding purposes; in order to show what a practical and important movement is here taking place, and how much the influence of pure Science is apt to be underrated, until its material applications become manifest.

The rapidly increasing demand for quinine was likely soon to have materially exceeded the supply from South America, but the success which has attended the acclimatization of the plant in India has removed all apprehension on that head; and the benefits to be derived from the new industry are rendered more certain and immediate by the fact that the young tree yields even a larger supply of quinine than it does in the more advanced stages of its growth.

The scheme of transporting salmon to Australia has not been so successful as the foregoing experiment, but as we feel sure that the labours of the enterprising acclimatizers will ultimately be crowned with success, and will yield a rich harvest to the inhabitants of the Australian continent, and, we trust, to the initiators themselves, we shall devote a page to the narrative of their efforts, and hope that a little influential assistance may thereby be enlisted in their cause.

We would first observe, that there are few features in the history of acclimatization so satisfactory as the success which has attended the introduction of the natural products of Great Britain into Australia. Those who visited the Exhibition of 1862 cannot fail to recollect the

* It is but just to mention, in connection with this topic, the names of Mr. Hartnup, of Liverpool, and Professor P. Smyth, of Edinburgh, to whom the scientific world (and more especially the maritime community) is indebted for many improvements in these instruments and appliances.

wax models of the acclimatized fruits of that continent. The full ears of wheat, the long silky locks of wool, and the long-stapled cotton (the latter introduced into Queensland from various quarters of the Old and New World), must be equally well remembered by all who visited the Colonial Courts.

And now we come to the novel, and not less useful, salmon-breeding experiments. This enterprise was commenced as far back as 1852, we believe, under the auspices of Sir George Grey, of whose efforts to improve the natural productions of the colonies placed under his charge it is hardly possible to speak in sufficiently laudatory terms.

The first experiment failed completely, notwithstanding that fifty thousand ova of salmon and trout were procured and employed in the attempt; and that every precaution was taken to ensure their successful transport. The failure is attributed chiefly to the absence of a continuous stream of water through the hatching apparatus.

For eight years the matter was allowed to rest, no fresh action being taken, but in 1860 a second expedition was fitted out with the same object. Owing to the failure of the precautions which were taken to resist the high temperature of the tropics, and other causes, this attempt was equally unfortunate, and entailed upon a few private individuals a loss of 650*l*. The colonial governments now joined in the enterprise; that of Tasmania, in conjunction with two other legislatures, voting an aggregate sum of 3,700*l*. for a third effort. Careful preliminary experiments were tried in England by scientific men, and vessels were then fitted out specially for the transport of the ova, an apparatus being provided for securing a constant flow of water, as well as for the maintenance of a suitable temperature.

Again, however, the attempt was unsuccessful; the failure in this instance being attributed chiefly to the disturbance of the water in which the young fry, hatched during the voyage, were contained, caused by the violent rocking of the ship. The young fish were dashed against the sides of the apparatus and destroyed. It will not be long, however, before another effort is made to accomplish the desired end, and it is believed that the experience so dearly purchased, will render the next attempt successful. There will be no difficulty, it is thought, in eventually perpetuating the breed of salmon in the antipodes, more especially in Van Diemen's Land, where the rivers already contain a variety of trout; but it is considered doubtful whether this can be extended to New Zealand, where the streams are rapid, and subject to violent floods.

Having thus noticed some of the strictly practical applications of the science, we cannot pass away from the question of acclimatization

without referring to the interesting experiment which has been so successfully carried out by our neighbours across the Channel.

The "Jardin d'Acclimatation" may be considered an ornamental and an educational, as well as a practical undertaking; and the admirable combination of art and nature, displaying as it does, in the highest degree, the characteristic taste of the French people, is eminently deserving of commendation. We trust that the time is not far distant when the inhabitants and visitors in the metropolis will have an opportunity of participating in as great a pleasure as that which may now be enjoyed by visitors to the French capital.

All questions regarding man's origin, or his relations to the lower animals, and concerning the connection or differences between the various races of mankind, will receive the earliest consideration of the writers in this Journal. They are *par excellence* topics of the day, and will probably long remain so; and should any of our readers regard them as mere matters of speculation, interesting only to naturalists, or doubt their practical bearing upon society, we recommend them to read the report of the discussion which took place concerning the Negro, at the Newcastle Meeting of the British Association.

At the close of a paper on "The Physical and Mental Character of the Negro," its author, Dr. Hunt, the President of the Anthropological Society, summed up his views as follows:—

"1st. That there is as good reason for classifying the Negro as a distinct species from the European, as there is for making the ass a distinct species from the zebra. 2nd. That the Negro is inferior, intellectually, to the European. 3rd. That the analogies are far more numerous between the Negro and apes, than between the European and apes."

"No man," he continued, "who thoroughly investigates with an unbiassed mind, can doubt that the Negro belongs to a distinct type of Man to the European. This word species, in the present state of science, is not satisfactory; but we may safely say that there is in the Negro that assemblage of evidence which would *ipso facto* induce an unbiassed observer to make the European and Negro two distinct types of man. My second and third proposition must be equally patent to all who have examined the facts."

And there appears to have been great unanimity in the opinions held by the officers of this nascent society, for, in the subsequent discussion, its secretary declared, in confirmation of the views of his chief, that wherever intellectual superiority exists in a man of colour, he is always found to have an admixture of white blood in his veins. In the section in which these statements were made (the Geographical and Ethnological), there were unfortunately but few physiolo-

gists present; and the warmest defender of the poor Negro was a gentleman of colour, whose remarks had a moral rather than a scientific bearing. It is possible that there may since have been a fair discussion on the subject which has escaped our notice; but be this as it may, there is no reason why the question should not be fully debated in these pages; and it appears to us that the discussion should be based not upon what is "not satisfactory" in the present state of science, but upon its acknowledged truths.

For ourselves, we do not hesitate to say that we completely differ from much that is contained in the foregoing doctrines, and that they appear to us to be at variance with the opinions and evidence of the most advanced physiologists. If the term "species" be unsatisfactory, we apprehend that its definition has not been rendered clearer by those who state that there is as good reason for placing the black and white man in distinct species, as there is for classifying the ass and zebra in the same manner, ignoring the question of hybridity; but, on the other hand, the admission that an intercrossing of the white and black races has a tendency to develope the intellectual faculties of the latter, and elevate the Negro to the level of the white man, seems to us to be pretty strong evidence that both belong to the same species, and partake of the same nature.

One of the local journals (which by the way reported the proceedings of the Association in a manner that has called forth the admiration of the scientific world*) did not hesitate to hint broadly, that the gentlemen who thus sought to degrade the Negro race, were the tools of the Southern Confederacy, and had been enlisted as the champions of slavery in England.

With regard to man's relations to the lower animals, and his nature and condition prior to the historic era, the opinions of some physiologists are becoming more and more divergent from the views hitherto entertained by the community; and stepping past the most extreme palæontologists of our day in this respect, a new and apparently careful thinker does not hesitate to present himself to the scientific world, and declare that he believes the fossil human remains which were found about six years since in the Neanderthal, near Elberfield, to have constituted the framework of a being endowed with no psychical powers beyond those which would enable it to provide its food and shelter, and possessing neither intellectual nor religious attributes.†

From the consideration of the highest born creature to that of the "Monad," is but a step in the unity of animal life, and the question

* The 'Newcastle Chronicle.'

† See the Report of Professor King's paper read before the British Association, and his article, in the present number, on the Neanderthal Man.

of the origin of man now stands side by side with that of the lowest living types of existence. An eminent physiologist of our day has hinted that it may be possible, before half a century has elapsed, for a man to take inorganic substances such as carbonic acid, ammonia, water and salines, "and be able to build them up into protein matter," and that that protein matter should "begin to live in an organic form." * On the other hand a French geologist of note has in a most solemn manner protested against the presumption of the man who seeks in his laboratory to compete with the Creator! † Both these writers are disbelievers in the theory of "spontaneous generation," and it is in the treatment of this question that they have expressed such opposite views. Whilst we must admit that at present we have grave doubts of Man being able to accomplish such a feat as is here described within the prescribed period, if at all, we confess that we regard without the slightest religious apprehension, any experiments that may be undertaken with this object. The stronghold of life appears to be as safe as it ever has been, and most assuredly, all that man can learn or effect, he is not only justified, but is bound by the gift of an intelligence second only to the Divine Intelligence, to attempt; and if, through his chemical, physical, and microscopical attainments, he should one day become a maker (a Creator he never can become) of living forms, it will only serve as an additional evidence of his vast destiny; and of the boundless powers and infinite wisdom of Him who can thus afford to reveal His secret places in nature to the inquiring gaze of Man. But at present the evidence which we possess on the subject, although of a negative character, is rather adverse to the doctrine of "heterogenesis"‡ in any form. A few words will suffice to explain the actual state of the inquiry.

At present there are three modes by which it is either known or suspected that living beings may be produced.

First, by "Spontaneous generation." That is to say, by the spontaneous combination of decaying organic matters, under certain conditions, and according to an unknown law, to form anew living, moving beings of the lowest known types.

Secondly (an allied form of heterogenesis), by the hand of man. That is to say, through the artificial application of physical or chemical forces and agencies to inorganic substances in the laboratory.

Thirdly, through the operation of the parental law only. In this case the ordinance must have ceased to exist, under which the lower

* Professor Huxley, 'Lectures to Working Men.'

† M. Boucher de Perthes, "Avons-nous Père et Mère?" (This is not said in reference to any particular observer.)

‡ "Heterogenesis" is a term employed to express the creation or birth of living beings in an abnormal manner.

forms of matter were originally combined to form a living being, and the sexual law substituted; one or two pre-existing germs, either active or in a state of rest, being needful for the production of a new being.

But, lastly, it is *possible* that *all* the foregoing laws may be in operation, inasmuch as no one of them necessarily interferes with another.

The evidence in favour of the doctrine of spontaneous generation, is found in the appearance of certain obscure moving types, of infinitely small proportions, in decaying substances, notwithstanding every effort on the part of man to exclude the germs of life in any form. That in favour of the artificial production, by man, of the lowest living types, is of a still more dubious character. It consists in the fact that out of inorganic substances he has been able to make a few organic compounds, such as urea, butyric acid, &c.; but our readers will see clearly that to make an *inanimate* complex substance from other inanimate simple substances, though we may call the former "organic" (in consequence of their usual origin), and the latter "inorganic," is a process widely different from that of making a living, moving, sentient being. Still the latter is not impossible, and if man do succeed in making such a being, and it be endowed with animation by the Giver of Life, he will but have added to his responsibilities, as he every day multiplies them, by the acquisition of fresh knowledge.

But having thus granted a fair hearing to the advocates of the "spontaneous generation" theory, and to those who propound the second doctrine, we feel bound to state that the evidence against both multiplies day by day. It is found, first, in the constantly accumulating proofs in favour of the parental law. One after another, types which were supposed to have been spontaneously generated, from insects down to infusoria, are found to exist as germs or ova, either in the water, in other living beings, in decaying bodies or animal substances, or, as it has been recently shown by French and English observers, to an enormous extent in the atmosphere which we breathe. It has been proved, too, that the tenacity of life which these germs possess is very great; enabling them to defy the hand of time or the destructive power of chemical and physical agencies, and these facts, coupled with the abnormal conditions under which such germs are able to exist after the resuscitation of life, will probably, for some time, defy the attempts of even the most careful and conscientious experimentalists to define satisfactorily under what circumstances the lowest known types first spring into existence.

But we must now take our departure from the field of natural history, and return once more to the consideration of those topics which

more immediately affect the progress of civilization; and in order to enable us to do so, we shall be compelled for the present to pass over many questions of interest in chemical and physical science.*

Amongst these are the discoveries of new metals, such as thallium, indium, &c., by spectrum analysis; researches in organic and inorganic chemistry by eminent English and foreign experimentalists, and the important and interesting experiments upon the nature of heat, by our own physicist, Professor Tyndall, as well as all those medical and chirurgical discoveries which have added to the duration of human life or alleviated physical pain; and we shall now refer cursorily to a few features in the progress of Mechanical Science.

It must often appear marvellous to the uninitiated, that the hand of man is able to accomplish works in civil or military engineering, in comparison with which the labours of Vulcan appear puerile and insignificant. But there is one instrument alone, which, since the introduction of steam, has afforded almost unlimited facilities for the employment and fabrication of the coarser metals; we refer to the steam hammer. When this tool was first introduced, about twenty or twenty-five years since, the weight of the hammer was about five hundredweight, whilst that of the instruments now employed in the forging of guns, large shafts, and similar descriptions of work, in some cases attains to forty tons. And it is even stated that there is now one in course of construction at Sheffield, intended for the forging of armour-plates, of nearly one hundred tons. The rapid development of this almost superhuman power, then, is alone able to account for the tremendous results obtained from modern implements of warfare, and for the obstinacy with which these are resisted by modern armour.

But it is not only in its gigantic features that mechanical science is making such rapid strides. The various woods which served the purposes of our forefathers are, indeed, still largely employed, but they are no longer fashioned by the hand of man. Steam and machinery now perform every kind of work with greater accuracy and economy than did formerly muscle and bone, and we have our mechanism for sawing, planing, grooving, tongueing, carving, and indeed for every similar operation.

And through the observations and experiments of men, eminent in physical science, we may calculate upon a greatly increased efficiency of the motive power and its application to almost every kind of manufacturing industry.

Steam, to which in the eyes of most of our readers nothing

* A full *résumé* of the progress of these branches of science will, however, be found in our 'Chronicles.'

can well be added, is itself susceptible, popularly speaking, of a further development, and what is known amongst engineers as superheating, is now daily acquiring a greater amount of favour. The process and its effect are simple and easily understood.

In its passage from the boiler to the cylinder, where its work has to be performed, the steam loses a certain amount of heat; in other words, a portion of it becomes condensed into water; and in addition to this, a certain proportion of partially vaporized water passes from the body of that liquid in the boiler along with the current of steam into the cylinder. The steam thus deteriorated is, according to the more recent plan, "superheated" in its passage, the result being an improvement in its quality: for owing to its more perfect vaporization and its increased temperature on its arrival in the cylinder, it possesses more elasticity, and necessarily a greater impelling power. The superheating process is performed by allowing the steam to pass through an apparatus of tubes, around which the flame or heated gases and atmospheric air circulate in their passage from the boiler to the chimney, thus converting the water-charged steam into elastic vapour, or what is technically called dry steam; and utilizing an amount of heat which would otherwise have been wasted.

Another equally simple, useful, and interesting improvement in engineering science, is "surface condensing." The ultimate effect is the same as that of the foregoing process, namely, an acquisition of power without any additional expenditure of fuel. No doubt our readers will have frequently observed a jet of steam passing into the sea from the hulls of steam-vessels. This is the partially condensed steam, after it has done its work in the cylinder; and in order to supply its place, a fresh stream of cold sea-water is admitted into the boiler. The object of surface-condensing is to save the steam by converting it into warm water and returning it to the boiler. The apparatus somewhat resembles the last-named; but cold water for condensing takes the place of steam for superheating. Instead of the cold sea-water passing into the condenser, there to be *mixed* with the steam and pumped off again along with it, the steam alone passes through tubes in the condenser, and around these, there flows a current of cold sea-water, which is subsequently pumped out, without having come in direct contact with the steam. The latter is returned into the boiler, and thus, instead of cold water charged with saline matter, that vessel is supplied with distilled water at a temperature of 100° to 120°. The foregoing observations apply to the condensation of waste steam from the ordinary low-pressure engine, but a still further improvement has been added, inasmuch as the steam usually ejected into the atmosphere from the high-pressure engine is now conducted into the vacuum in the

cylinder of a low-pressure engine, working in conjunction with the former, and thence through the surface-condensing apparatus back into the boiler in the form of heated distilled water, thus practically working two distinct engines.*

These are but two of the improvements which have been introduced into a single branch of mechanical science, and if our space allowed it, we might touch upon many others in its various sections. We could speak of the advances in railway travelling, especially over short distances, and underground, instancing the Metropolitan Railway, with its convenient carriages, excellent system of lighting and signalling, and consequently the comparative safety with which the trains pass to and fro. We might refer to the introduction of coal-cutting machinery,† which will, we trust, one of these days, put an end to the destruction of human beings under the most terrible circumstances that can be conceived; to the improvements in machinery for the utilization of hitherto waste products, and new substances, and which along with others already named, could not in their turn be accomplished but for the employment of improved forms of iron, such as the cheaper steels and semi-steels, homogeneous metal, malleable cast-iron, &c.; but our readers must be content with these passing remarks on the progress of Mechanical Science, and pass on with us to the last subject which demands our notice, and without which our work would be far from complete.

We now refer, not to any special branch of science or human industry, but to the progress of scientific education, and that chiefly in our own country.

Whether this be effected by means of Philosophical Institutions for the middle and higher classes; in the University Lecture Hall for students, or through the machinery of the Science and Art Department of the State; it is entitled to, and will receive, our earnest consideration; and as far as the nature of our work admits, a warm support will be accorded to Science instructors of every rank and station; indeed it will be our earnest desire, however limited may be our influence, to promote the welfare of all scientific men, from the most illustrious observer, to the humblest labourer in the fields of Science.

And now, conscious that in this extended but hasty survey, we must have said much that is open to doubt and criticism, and left unsaid

* Of the two steamers 'Hibernian' and 'Bohemian,' both of which are about the same tonnage, plying between Liverpool and Canada, the former is fitted with a surface-condenser, but not the latter. The former consumes 44 tons of coals per day, and makes 12½ knots per hour; the latter requires 55 tons per day, and steams only 11 knots per hour.

† Concerning which, some valuable information will be found in the present number of our Journal.

many things which readier pens or abler minds would have treated with accuracy and clearness, we have a few parting words to add to our readers, and more especially to a large class to whom we look for considerable support, and who may do much to facilitate our labours; we mean ministers of religion.

It would avail us little, if, after intimating, as we have done in the preceding pages, that the social, and even the political bearings of Science will not be overlooked, we were to remain silent on the great question of Theology. To do this, would be simply to arouse suspicion, and lead to misconstructions which a frank exposition of our views may obviate: and we have less hesitation in approaching so delicate a question, from the conviction that however adverse may be the views of individuals, or even, here and there, of some body of narrow-minded theologians, a vast majority of our religious teachers look with anxiety, and without apprehension, upon each new revelation of the laws of nature, and watch with interest its bearings upon theological inquiry. Scientific knowledge will never lower man's religious nature, nor render it any less devotional, unless it be employed for worldly purposes, or perverted to private ends by the promptings of passion. Sound Science must make *some* enemies, for, as we have already said, it drives superstition before it, as chaff is driven before the wind, and it may answer this or that prophet of our day to sneer at its propounders as self-righteous, or to hold them up to scorn as infidels; but every sincere and devoted preacher of the Truth, knows it to be not only to his interest, but that it is indispensable that he should be acquainted with other branches of knowledge than those immediately connected with his vocation, and that he should at least march abreast with, if not precede, the foremost rank of lay intelligence. That many such inquiring men will be amongst our readers, as they may already be found amongst our contributors, we have no doubt whatever, and the question arises, how shall we deal with such subjects as are supposed to have a more or less direct bearing upon Theology?

There need be no hesitation in furnishing the reply.

It would ill serve the ends of truth in any form, if we were to interfere with the free discussion of scientific topics on the ground that the views enunciated might give offence to the believers in some particular theological doctrine. Such a course would defeat rather than promote the ends of true religion, and it may even be necessary that we should now and then be tolerant of the expressions of what may appear erroneous or extreme views, for the purpose of ultimately eliminating the truth. Whilst, however, we have too much faith in the good taste and right feeling of our collaborateurs to suppose that freedom of discussion would ever be employed as a cloak for irreverence, we

are bound to state that it will not be with our cognizance or sanction, if any expression in the slightest degree savouring of this quality finds its way into our Journal; and we add this, not to curry favour with those to whom these remarks are more particularly addressed, but in order that persons who are anxious to consult these pages with a view to the acquisition of sound science for the purposes of religious teaching, may not be driven away, to make place for others of a less friendly disposition, whose aim will be to detect heresy, or to turn the revelations of nature into a means of upholding superstition.

The cause of science may be advocated on the ground that it tends to the comfort and material prosperity of the human race; or because it serves to elevate man's intellect, and to enable him better to fulfil his brief mission on Earth; but its highest title to a foremost place in the literature and teachings of the day is found, not in either of these advantages, but in the fact that by disciplining the minds of men it imparts to them a purer and more elevated conception of the Creator, and prepares them for the comprehension of the highest truths, thus helping to fit them for a purely spiritual existence.

ORIGINAL ARTICLES.

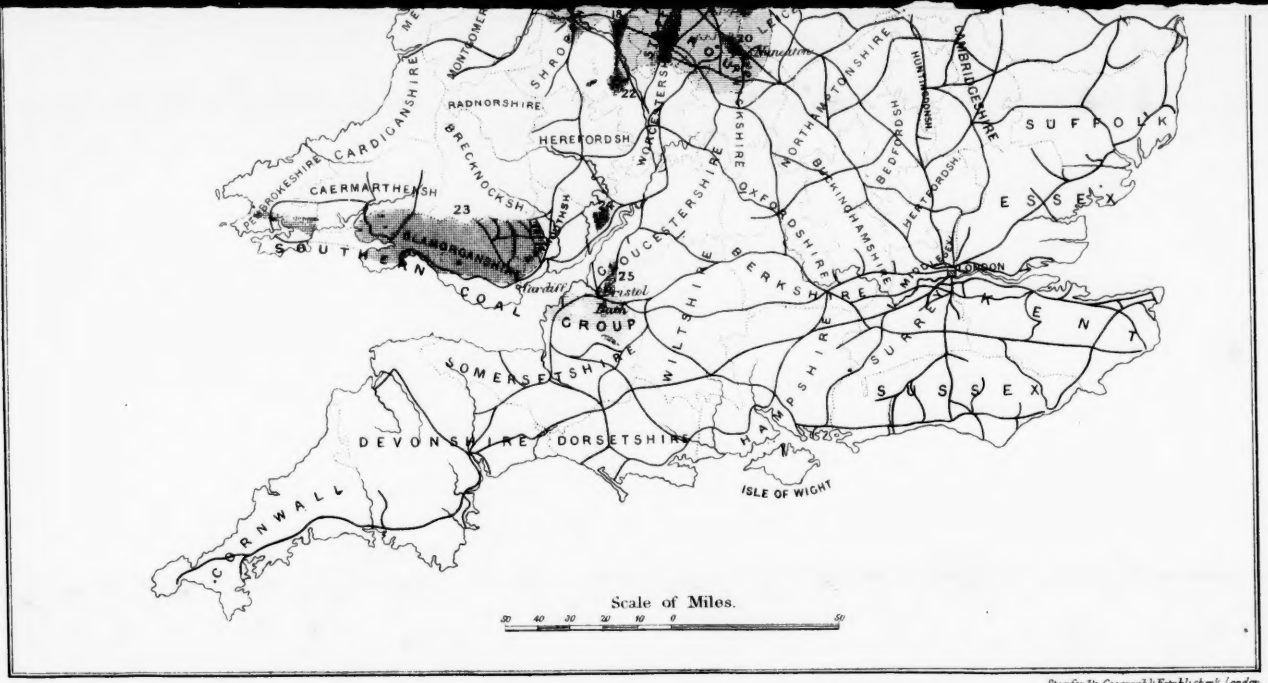
THE COAL RESOURCES OF GREAT BRITAIN.

By Edward Hull, B.A, F.G.S., of the Geological Survey of Great Britain.

Of all sciences, none, perhaps, is so generally regarded as devoid of practical application as Geology. The employment of Astronomy in Navigation is known to all; the numberless uses of Chemistry in the Arts are self-evident; Mineralogy is, of course, of value in detecting minerals; Physics, in laying down the principles of the electric telegraph, and Mechanics, in the construction of machinery. But Geology! "what *can* be the use of Geology?" asks the world. If you answer that it has served to throw a flood of light on the past history of our globe, such a reply will not satisfy the utilitarian; and the "practical" miner will say (though erroneously) that he can work his way in the earth in search of the minerals as well without, as with, a knowledge of Geology. To all such inquiries, as to the practical use of this science, let me proceed to give a final answer. Premising that Geology is capable of application in the elucidation of a number of questions affecting our every-day life, which cannot be dwelt upon here, I may state that it is pre-eminently useful, and indispensable in enabling us to estimate the extent of those stores of mineral fuel which Providence has laid up in the strata of the earth for the service of man.

The coal stored up in the bowels of the earth is limited in quantity, and, like the Sibylline Books, when once burnt, is irrecoverable; every day sees this store diminished; and just as the master of a house, at the approach of winter, wishes to ascertain the quantity of fuel in his cellar, so must it be a subject of moment to us as a nation—depending as we do so largely on the supply of coal for our manufacturing, commercial, and even political, pre-eminence,—to ascertain as far as possible, to what extent we may reckon on the continuance of this great source of motive power. Without the aid of the science of Geology, such an inquiry could only have ended in disappointment; with it we have all the materials necessary for the solution of the problem, as far at least as regards the actual quantity of coal itself.

The strata, or "measures," containing the beds of coal, belong, for the most part, to the great Carboniferous System of Rocks. They occur generally under two modes of arrangement; either as "basins"



Stanford's Geographical Establishment London.

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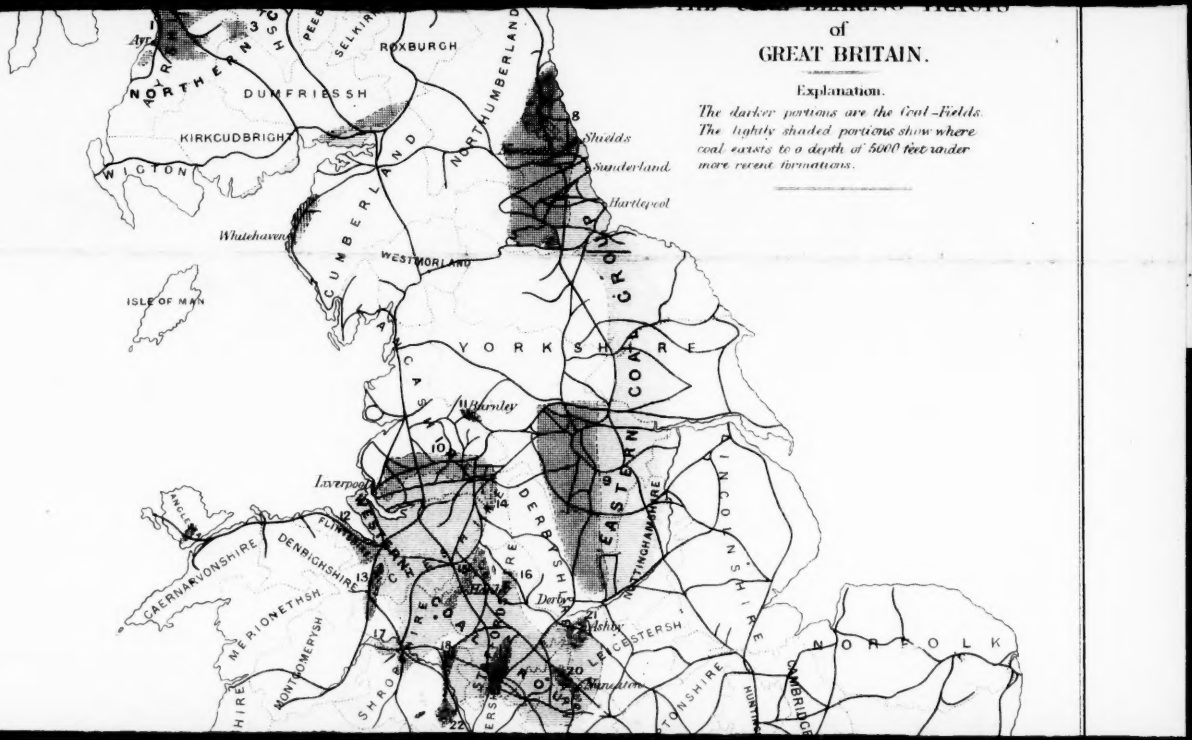
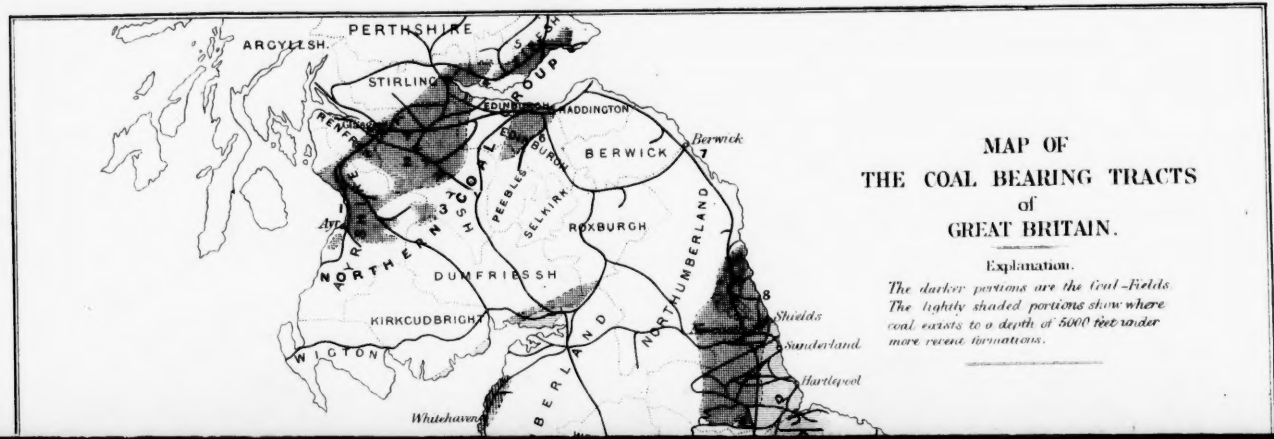

of
GREAT BRITAIN.
Explanation.
The darker portions are the Coal-Fields.
The lightly shaded portions show where coal exists to a depth of 5000 feet under more recent formations.
NORTHERN COAL FIELD
NORTHUMBERLAND
DURHAM
ROXBURGH
DUMFRIESSH
KIRKCUDBRIGHT
WIGTON
CUMBERLAND
WESTMORLAND
Whitehaven
ISLE OF MAN
Shields
Sunderland
Hartlepool
YORKSHIRE
Wakefield
Liverpool
WESTERN COAL FIELD
ANGLESEA
CAERNARVONSHIRE
DENBIGHSHIRE
FLINTSHIRE
MERIONETHSH
MONTGOMERYSH
SHROPSHIRE COAL FIELD
EASTERN COAL FIELD
DERBYSH
Derby
NOTTINGHAMSHIRE
LINCOLNSHIRE
LEICESTERSH
Ashby
Nuneaton
NORFOLK
CAMBRIDGE
HUNTINGTONSHIRE


PERTHSHIRE
ARGYLLSH.
STIRLING
EDINBURGH
HADDINGTON
BERWICK
Berwick
SELKIRK
PEEBLES
ROXBURGH
DUMFRIESSH
KIRKCUDBRIGHT
WIGTON
NORTHUMBERLAND
Shields
Sunderland
Hartlepool
Whitehaven
MAP OF
THE COAL BEARING TRACTS
of
GREAT BRITAIN.
Explanation.
The darker portions are the Coal-Fields
The lighly shaded portions show where
coal exists to a depth of 5000 feet under
more recent formations.

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or "fields:" and on the threshold of our inquiry it may be well to give a short sketch of each of these systems.

FIG. 1.—*Section of the Forest of Dean Coal-Basin.*

1. Coal-Measures. 2. Millstone Grit. 3. Mountain Limestone.

Coal-basin.—The section of a coal-basin is represented in the above woodcut. The term is used when the beds dip from every part of the circumference towards the centre. When the basin is elongated in one direction to a considerable degree, it is called a "trough;" but as it is rare for any coal-bearing tract to be even approximately symmetrical, the term "basin" serves to denote all such tracts, whether the outline be circular or oval. To this form belongs the largest coal-tract in Britain—the South Wales Coal-field (No. 23 in Map), as also that of the Forest of Dean (24), and several others.

FIG. 2.—*Section of the Yorkshire Coal-Field.*

1. Magnesian Limestone.
2. Permian Sandstone.
3. Coal-Measures.
4. Millstone Grit.
5. Limestone Shale.
6. Mountain Limestone.

Coal-field.—In the case of a coal-field, the strata dip (with more or less regularity) in one direction. Such an arrangement has many modifications; either the strata dip under those of a more recent formation, as in the case of the Yorkshire Coal-field (Fig. 2), or they are cut off along one side by a fault, as in the Anglesea coal-field. This is the more general form which a coal-tract assumes, and is often much varied by rolls in the strata, or by dislocations.

Coal-group.—Where the strata of several coal-fields dip towards each other, and under those of a newer formation, such as the New Red Sandstone, it may generally be inferred that they are connected underneath, and that if the newer formation were penetrated, the coal-measures could be reached beneath. When several of these coal-fields are thus physically connected, they give rise to what may be called "a group of coal-fields," or simply a "coal-group." Under the same title we also place a number of distinct *basins* or *fields*, which were originally connected, but have since been dissevered by denudation, as those of the central valley of Scotland. In this manner the British coal-areas naturally arrange themselves into four groups, which, on the map, have been marked as the Northern, Western, Eastern, and Southern coal-groups. These great divisions refer more immediately to the *present* arrangement of the tracts than to that which they assumed at the time of their formation. Nevertheless there is reason to believe that out of the four only two were originally continuous with one another, namely, the eastern and western groups. From this

great sheet of coal-bearing strata which once stretched right across our island from sea to sea, and even farther, the northern and the southern coal-groups were both separated, the latter by a barrier of land, the former by difference of age; for we now know that coal was in process of formation in Scotland while the Carboniferous limestone was accumulating in the sea-bed over the English area. The following are the subdivisions or fields of the several groups.

Northern Coal-group of Scotland.*

Comprehending—1, the Coal-fields of Ayrshire; 2, Clyde basin; 3, Lesmahago basin; 4, Clackmannan; 5, Fifeshire; 6, The Lothians.

Eastern Group (*England*).

8, Great Northern Coal-field of Northumberland and Durham; 9, Derbyshire, Yorkshire, and Notts (only one coal-field).

Western Group (*England and Wales*).

10, Lancashire; 11, Burnley basin; 12, Flintshire; 13, Denbighshire; 14, Poynton; 15, North Staffordshire; 16, Cheadle; 17, Shrewsbury; 18, Colebrook Dale; 19, South Staffordshire; 20, Warwickshire; 21, Leicestershire; 22, Forest of Wyre.

Southern Group (*England and Wales*).

23, Forest of Dean basin; 24, Somersetshire; 25, South Wales basin. Besides the above enumerated, there are several small detached fields, such as those of the Border, on the north side of the Solway Firth, Whitehaven, and Anglesea.

The two great coal-fields of the Eastern group are, in all probability, connected by a tract of coal-measures underlying the Triassic and Permian formations along the east of Yorkshire, as indicated by the shading on the map. The numerous fields of the Western group are, without doubt, physically connected underneath the New Red Sandstone of Cheshire and Staffordshire; and, as already stated, those of the Southern group were, in their original state, joined together.

Having thus cleared the way by a survey of the general structure and arrangement of the coal-groups, we are now prepared to enter upon an examination of the resources of the more important of the fields and basins.

Northern Coal-group.

Having already enumerated the members of this group, we must content ourselves with treating them as a whole, because, with the exception of two or three distinct fields, such as that of the Lothians, Fife, and Lesmahago, the coal-bearing rocks of Scotland are all physically connected, and the structure of each is too complicated to allow of treating them in detail within the space at my disposal.

The coal-formation of Scotland belongs, for the most, to the

* The numbers refer to those on the Map.

lower Carboniferous series, and is therefore of greater antiquity than that of England. It occupies the broad valley stretching from the Firth of Forth to the Firth of Clyde, and is bounded on the north by the frontiers of the Highlands, and on the south, by the hilly and wild tract which gives birth to the sources of the Tweed. The coal-seams are often interrupted by the intrusion of igneous rocks, and in some places, the older Carboniferous and Devonian formations rise to the surface, and terminate the continuity of the beds. There is documentary evidence to show that coal was worked in Scotland from at least the fourteenth century,* and the Celtic name for the mineral is still preserved in that of a little tarn, called Lough Glo. The total area of workable coal equals 1,720 square miles, and the total available supply of coal to a depth of 4,000 feet, amounts to 25,300 millions of tons.† The quantity raised in 1861, was 11,081,000 tons from 424 collieries.‡ In this is included the double coal-trough of the Lothians —the resources of which were calculated with much labour by Mr. Milne-Hulme and Mr. S. Nicol, several years ago. It will be seen from the above estimates, that there is coal enough to last at the present rate of consumption for about 2,000 years.

EASTERN COAL-GROUP.

The Great Northern Coal-field.—The resources of this district have been more fully illustrated than those of any other coal-field in England. No less than six distinct estimates having been made, and they all come to very nearly the same conclusion regarding the available quantity of coal at the time specified by each.

The coal-field extends from the mouth of the Coquet, on the north, to that of the Tyne on the south, a distance of fifty miles. The strata dip generally eastward, and are ultimately concealed beneath the table-land of the Magnesian Limestone, which is now penetrated by shafts in search of the subordinate coal-beds. The actual coal-field has an area of 460 square miles, but to this we must add the area overspread by the Magnesian Limestone, and other formations of more recent age—that is, 225 square miles—making in all 685 miles, and containing about 7,200 millions of tons of available coal. This coal-field has from the infancy of mining been one of the greatest producers; and from its store the Metropolis of the Empire has principally been supplied. The consumption is still steadily increasing,

* Æneï Sylvii Opera, p. 443.

† 'Coal-fields of Great Britain,' 2nd edit., p. 179. I must here apologize to the reader for quoting myself, which I do for the simple reason that there is no other authority extant for the resources of all the British Coal-fields, though there are for a few special ones which shall be stated. The calculations contained in my work were made with much care, and have been used by Sir W. Armstrong, President of the British Association. I may here state, in order to avoid the appearance of dogmatism, that in dealing with so large a question as the number of tons of coal in any of our coal-fields, the figures do not pretend to be more than close approximations to the reality, but it would be a useless repetition to place before each group of figures such words as "about," "approximately," "nearly," &c., which the reader is requested mentally to introduce for himself.

‡ Hunt's 'Mineral Statistics of Great Britain' for 1861.

and in 1861 reached 19,144,965 tons. Supposing the amount to reach 20 millions, the supply would last 360 years. The calculation of Mr. T. Y. Hall, in 1854, was 365 years.

Coal-field of Yorkshire, Derbyshire, and Notts.—This is the largest coal-field in England, and extends from Bradford and Leeds on the north, nearly to Derby and Nottingham on the south, a length of sixty miles. Towards the northern outcrop, the strata, which had previously maintained a meridional direction throughout a distance of about fifty miles, suddenly bend round at right-angles, and trending eastward, are ultimately lost beneath the Magnesian Limestone which passes over their edges, and rests on the Millstone Grit. The same beds again re-appear in the northern coal-field, and there is good reason for believing, with Professor Phillips, that these two districts are physically connected beneath the more recent formations, as indicated on the map by the faint shading.

The general dip of the coal-strata is eastward; but there are several rolls or troughs running north and south through the centre of the field. The coal, which is of very fine quality, is known as "splint," from its splintery fractures.

In estimating the resources, a considerable addition must be made to the area of the actual coal-field, for the available coal-ground concealed beneath the Magnesian Limestone and Trias on the east, amounts to probably one-half as much again. The exact distance to which the coal-measures extend in this direction is, of course, at present a matter of conjecture, and will probably never be known, as the overlying strata increase in thickness the further we proceed eastwards; but the distance is certainly considerable. The Permian beds have already been pierced in several places by collieries, one of the most remarkable being that recently sunk on the property of the Duke of Newcastle at Shireoaks, in which the Permian beds were found to be 66 yards in thickness. Taking the area of the coal-field at 760 square miles, and that of the available ground occupied by the Magnesian Limestone at 400, there will thus be 1,160 square miles with coal, an area larger than the coal-basin of South Wales, and only less than that of Scotland. The available quantity of coal will not fall short of 16,800 millions of tons. The quantity raised in 1861 was 14,490,919 tons, so that at this rate of consumption there is sufficient to last for upwards of a thousand years. There were in 1861 about 577 collieries, of which only five passed through the Magnesian Limestone in 1859.*

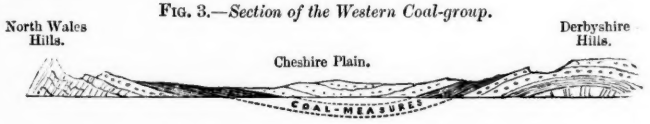
The Western Coal-group.

The Western Coal-Group is bounded on the north by the Lancashire coal-field, on the east by those of North Staffordshire, Leicestershire, and Warwickshire; on the south by those of South Staffordshire and Shropshire, and on the west by those of Denbigh and Flintshire. The strata of these respective coal-fields have a general dip towards the centre of this great basin, which is occupied by Triassic and Per-

* As I am informed by Mr. C. Morton, Her Majesty's Inspector. There may have been a few more since that time.

mian beds, and there can scarcely be a question that the coal-formation extends underneath over the whole area (as represented in the map), though often at very great depths. The following diagram (Fig. 3) will give an idea of the manner in which the Carboniferous beds rise from beneath the newer formations at the eastern and western sides of the basin.

FIG. 3.—*Section of the Western Coal-group.*



The mineral resources of this vast area, which is not less than 4,700 square miles, are practically inexhaustible were it possible to work the coal over the whole of it, but such an idea is altogether visionary, as the overlying formations often attain a thickness of 5,000 feet, which would have to be passed through before reaching the first seam. I shall hereafter endeavour to show that such a depth is probably beyond the reach of mining enterprise, at least with our present mechanical appliances. I therefore pass at once to the consideration of the available portion near the margin.

South Lancashire.—Owing to the great demand for coal arising from the extent of population and manufactures in this country, this coal-field is being heavily taxed. The area of the coal-bearing portion* is 192 square miles. The field extends from Rainford and Prescot on the west to Ashton-under-Lyne on the east, at which place it bends southward into Cheshire, and throws out a small arm as far as Poynton. The general dip of the strata is southward, and the seams descend under the Triassic rocks of Cheshire. Within a vertical limit of 4,000 feet there is an available quantity of coal to the extent of 3,700 millions of tons, and the quantity raised in 1861 was about 12 millions, at which rate of consumption the coal would last for about 300 years.

The Burnley Coal-basin.—This tract lies considerably to the north of the main field. It is in form a half-basin, bounded on the south-east side by a large fault. It has an area of 20 square miles, and a combined thickness of 40 feet of coal. The available quantity is about 270 millions of tons, and the annual yield about one million.

Flintshire and Denbighshire Coal-fields.—These two fields occupy the same general range of hills, rising above the Triassic plains of Cheshire and Salop. The former is rapidly approaching exhaustion, owing to the fact that the seams nowhere descend to any great depth, but are repeatedly brought to the surface by faults; consequently they have been largely worked in the days of shallow pits. At Mostyn, coal is worked under the sea, and attempts have been made to reach the seam beneath the New Red Sandstone. The area of the field is 35 square miles, and there remains for future supply little more than 20 millions of tons, of which the present generation may see the end.

* This is exclusive of the hilly district, in which there are occasional thin seams, known as "mountain mines."

The Denbighshire field, on the other hand, has a somewhat larger area, and holds a very much greater quantity of coal. It occupies about 47 square miles, and has an available store of 490 millions of tons. The seams dip eastward (*see* Fig. 3), under large tracts of Permian and Triassic beds, and were the minerals capable of being followed in the direction of the dip, the supply might be almost indefinitely extended. The quantity raised in 1861 from these two coal-fields, amounted to 1,870,250 tons.

North Staffordshire Coal-field.—Considering its extent, this is one of the richest, and at the same time least developed, coal-fields in Britain. With an area of 75 square miles, a vertical thickness of 5,000 feet of coal-bearing strata, containing 22 valuable seams, as well as several very rich beds of ironstone; there are only a few mines of any great depth, and a considerable portion of the district may be considered virgin ground. At the same time mining operations are being rapidly extended, so that between the years 1857–61, the quantity of coal raised had doubled itself, and in the latter year it reached 2,372,500 tons.

The shape of this coal-field is nearly triangular, with its apex to the north. Towards the south and west the coal measures dip at moderate angles under Permian and Triassic formations, which at no distant day will, in all probability, be invaded by collieries. The available supply of coal for future use is not less than 1,600 millions of tons, which is capable of sustaining the present drain for nearly 700 years.

The Cheadle coal-field is separated from that of North Staffordshire by a ridge of Millstone Grit, and contains only a few of the lower seams. In an economic point of view it is unimportant.

South Staffordshire Coal-field.—This coal-field is remarkable from the fact that it has been upheaved bodily through the Triassic rocks along two lines of dislocation which bound it on the east and west sides. Unlike that just described as in the freshness of youth, this may be considered as having passed the meridian of its career, and as being on the verge of old age. Its extraordinary richness has been the principal cause of its early decline, and the treasures easily acquired have been often recklessly squandered. No district in Britain has been more favoured by nature in the richness of its stores of coal and iron, but unfortunately for their efficient and economical working, they have been placed too near the surface, and consequently have been mined by means of a vast number of small, ill-managed coal-pits, instead of on a well-regulated system of mining, such as is involved in the working of more extensive collieries. In some places the water from the old excavations has been allowed to accumulate to such a degree that large areas are hopelessly drowned out, and in others much of the coal has been wasted. At the same time this mineral wealth has given rise to the concentration of an enormous amount of manufacturing industry, and the spectacle of blast-furnaces, foundries, coal and iron-pits, and houses interlaced by a network of canals, railways, and roads, which the "black country" presents, is familiar to most of our readers.

Over the southern half of the field—that is, south of the Bentley fault—a coal-seam no less than 30 feet thick is, or was, spread. It is called the "Dudley 10-yard seam," and is the thickest in England, if not in Britain. North of the fault it is split up into nine separate seams, which collectively form 30 feet of coal.* The area of the coal-field is 93 square miles, and of the original quantity of 3,000 millions of tons of coal, not more than 960 millions remain. The production of coal has of late years rapidly increased, and in 1861 it reached 7,253,750 tons from 580 collieries. Taking the future production at eight millions of tons, the coal would last 120 years.

Colebrook Dale Coal-field.—This district is even further advanced towards exhaustion than the one we have just considered. The coal has been worked here more than a thousand years, for it was found in the ruins of Uriconium,† and, with the rich seams of ironstone, has laid the foundation of several celebrated iron manufactories. Over the larger part of the field both minerals have been already worked out, and the only place where they yet remain entire is along the eastern edge. The miles of country covered by mounds of slag, and waste heaps of former mines, bear witness, even to the casual passer-by, that the earth has been despoiled of all her treasures.

The area of the field is 28 square miles. The beds dip eastward, and may one day be followed under the Permian and New Red Sandstone; but there are certain irregularities in the stratification of this coal-field, that render it uncertain to what extent the beds of coal underlie the newer formations. Only one-third of the original quantity of workable coal remains, which we may place at 14 millions of tons. In 1861 the quantity raised was 829,750 tons, so that twenty years hence the coal will in all probability be exhausted.

Leicestershire Coal-field.—This is a small, but rich district, as it contains one seam 12 or 14 feet in thickness, and several others of value. On the Coleorton, or eastern side, there are several collieries which are situated on the Trias, and it was here, at Whitwick colliery, that George Stephenson, with that power of observation so remarkable in him, first came to the conclusion that the coal-measures dipped under the New Red Sandstone, and then demonstrated the fact by sinking a shaft to the main coal.‡

The area of this field is upwards of 15 square miles, of which a part is concealed by newer formations, with an available supply of 140 millions of tons. The quantity raised in 1861 was 740,000 tons.

Warwickshire Coal-field.—The position of this coal-field is interesting from the fact that it forms the farthest prolongation of the Carboniferous strata towards the south-east of England. It occupies a long and narrow strip of country, stretching from near Tamworth to Wyken, a distance of 15 miles. The strata dip to the south-west under large tracts of the Permian formation, where the coal lies at accessible depths, and will greatly prolong the resources of the district. The

* Mr. J. B. Jukes' 'Memoir on the North Staffordshire Coal-field,' 2nd edition.

† Or Wroxeter. Mr. T. Wright states that cinders were discovered under several of the hypocausts.

‡ Smiles' 'Life of G Stephenson.'

area of the coal-field is 30 square miles, and the available supply about 400 millions of tons, to which a very large addition must be made for the quantity underlying the Permian formation. In 1861 the produce of this coal-field was only 647,000 tons, which cannot be said to be in due proportion to the resources.

The small and but slightly productive districts of Shrewsbury, the Forest of Wye, and the Clee Hills, do not require special notice here, further than to intimate their existence.

Southern Coal-group.

Forest of Dean Coal-basin.—In structure, this is a more perfect basin than any in Britain, as the strata everywhere dip from the circumference towards the centre (Fig. 1). It is by no means opened up to the extent of its capabilities, and for the most part presents the aspect of rich forest scenery, with only an occasional coal-pit chimney at wide intervals rising in the midst of the trees. Its area is 34 square miles, and it contains about 560 millions of tons of available coal. The annual produce is about 1,000,000 tons, which in a few years will be considerably extended by the introduction of railways now in process of construction.

Bristol and Somersetshire Coal-basin.—The greater portion of this basin is uncomformably overlaid by a newer formation of Trias, through which the coal-measures only appear at intervals; yet its general form has been pretty well ascertained by means of collieries and borings. Including the parts occupied by Red Marl and Lias, the area is not less than 150 square miles, with 51 seams of coal distributed through 5,000 feet of strata. Of these seams, however, only 20 are of a thickness of 2 feet and upwards, and owing to some special physical impediments (such as the presence of the "Pennant Grit"), very large deductions require to be made before arriving at the available supply. This quantity I do not place at a higher figure than 2,000,000,000 tons. The produce for 1861 was 1,025,525 tons.

South Wales Coal-basin.—The greatest of our coal-basins is the last but one to be described. It is truly an astonishing reservoir of mineral fuel, whether we regard it for its actual area, not less than 910 square miles; the enormous thickness of the strata stored with coal, reaching 10,000 feet; the vertical accumulation of coal, stated by one authority to be from 70 to 100 feet in thickness;* or lastly, from the symmetrical form of its outline, which is nearly that of a pear. It is, in fact, an elongated basin or trough in which the strata dip towards the central axis, that axis itself at the same time coinciding with a great upheaval of the strata in the form of a roll or anticlinal. The coal-field is divided into three districts: the west, yielding anthracite; the centre, steam coal; and the east, bituminous coal. The richer beds lie near the bottom, and these are often placed within reach of mining operations by the great depth of the valleys, which penetrate for miles into the central high-lands, laying bare the strata many hundred feet.

* Mr. H. H. Vivian, 'Speech on the Coal Clause,' House of Commons, 1861.

The quantity of *available* coal yet remaining is, according to my own calculations, 24,000,000,000 tons. This is one-half the whole amount originally contained in the basin, a very large portion of which is at a depth below 4,000 and 5,000 feet. The produce of the 313 collieries in 1861 was 6,690,771 tons, which is considerably lower than in previous years, probably from the falling off in the export trade owing to the American war, but even should the amount reach ten millions of tons, there is enough to last 2,400 years, or to supply the whole consumption of Great Britain for about 300 years,—a fact which one might suppose ought to set the mind of the public at rest on the subject of our coal-resources.*

Cumberland Coal-field.—This being detached from any of the above groups, I have reserved for the last. It forms a small band stretching along the sea, from Whitehaven to Maryport, and has been worked from very ancient times, as we have documents showing that the seams had been followed under the sea as early as the beginning of the 18th century. The area of the coal-field is 25 square miles, and the quantity of coal remaining for use is about 90 millions of tons.

The following summary of the above shall conclude this part of the subject.

General Summary. †

Group.	Area, square miles.	Resources in millions of tons.	Produce, 1861.	Number of Collieries.
Northern . . .	1,920	25,300	11,081,000	424
Eastern	1,845	24,000	34,635,884	848
Western . . .	535	7,594	25,643,000	1,158
Southern . . .	1,094	26,560	13,201,796	516
Cumberland . .	25	90	1,255,644	28
	5,419	83,544	85,817,324	2,974

The above figures being rendered into words, mean that there are in Great Britain, within a depth of 4,000 feet from the surface, 83,544,000,000 of tons of coal available, and that this quantity divided by the quantity raised in 1861, say 86,000,000 of tons, would last for about 970 years.

Having thus determined approximately the resources of our coal-fields, and making no pretensions to prophecy, it might be wise, perhaps, to close this article without venturing one word regarding the future. Nothing is more liable to error than prospective statistics; the only person who is privileged to make use of them being the Chancellor of the Exchequer for the time being. At the same time, the falsifi-

* The estimates of Mr. Vivian are much larger than my own; but I think he has fallen into the error of multiplying the average thickness of coal into the full area; whereas the range of some seams is very far short of that.

† The produce and number of colleries are from the 'Mineral Statistics of Great Britain,' for 1861, by R. Hunt, F.R.S., but differently arranged to suit the classification into groups here adopted.

cations to which the estimates of this great functionary are often subject, may well be a warning to all would-be minor prophets not to venture on forbidden ground. We feel it, however, necessary to say a few words in vindication of what may appear the, somewhat arbitrary, limit of depth which we have adopted in the above calculations of our coal-resources. The reader will be justified in inquiring why we prefer 4,000 feet to 5,000 feet on the one hand, or 3,000 on the other, and he is therefore entitled to a reply, though it must be a brief one.

Taking the latter figure first, we may state at once that this depth has already been attained, or very nearly so, in more than one colliery, both in our own country and on the Continent,* and no colliery manager will maintain that the limit has been here reached.

With regard to 5,000 feet as a limit of depth the case is otherwise; for we have reason to conclude that supposing this depth to have been attained, the temperature, not to speak of other obstacles, would be found so high as to forbid the employment of human labour.

The increase of temperature as we penetrate from the surface, is a law which has been established on the evidence of a large number of observations in all parts of the world. In our own country very interesting and careful experiments have been made in several mines; both in the metallic mines of Cornwall, and the coal mines of the North of England.† Having on a previous occasion given the experiments in detail, the results need only be stated here, and are summarized in the following table, together with the temperatures calculated to a depth of 4,000 feet.

Table of Increase of Temperature for Depth.

Depth in feet.	Increase of Temperature due to Depth.	Increase due to Density of Air.	Resulting Temperature.
1,500	21·42	5·0	76·92
2,000	27·85	6·5	84·85
2,500	35·5	8·5	94·00
3,000	42·14	9·83	102·47
3,500	49·28	11·66	111·44
4,000	56·42	13·16	120·08

In the above table "the temperature of no variation" adopted, is 50·5° at a depth of 50 feet from the surface.

From the foregoing tables it will be seen that even at a depth of 4,000 feet, a temperature may be expected more than tropical, though less than it would be at 5,000 feet, and sufficient, we think, to place

* One shaft in Belgium, we are assured, is 932 yards in depth. In Saxony, there is another upwards of 800 yards; and in the Dukinfield Colliery, the black mine has been followed to the depth of 940 yards from the surface.

† Experiments made at Rose Bridge Colliery, Wigan, and Dukinfield Colliery, Ashton-under-Lyne, and detailed at length in the 'Coal-fields of Great Britain,' pp. 223–232. The latter were first published by Mr. W. Hopkins, F.R.S., in the 'Philosophical Transactions,' vol. cxlvii.

the limit of depth within the last-mentioned figure. The means by which the temperature even at 4,000 may be reduced so as to admit of healthful labour is ventilation, and the question remains, to what extent can this be accomplished. A series of interesting experiments undertaken at my request by Mr. Bryham, at Rose Bridge Colliery, Wigan, enables us to arrive at the following general conclusion:—that in a mine of ordinary extent, the temperature can be lowered by 20° or 30°, according to the distance from the shaft, and the season of the year. The cool air of winter reduces the heat of the mine more than that of summer time, so that even with a depth of 4,000 feet it may be often impossible to excavate the coal except during the colder months of the year.

Space will not admit of our doing more than to glance at the past history and future prospects of coal-mining. It may be said that up to the end of the last century, the art had only smouldered. It was when the invention of the steam-engine revolutionized the industry of this country, that mining burst forth with an energy previously unapproached. Probably not more than ten millions of tons of coal were raised at the commencement of this century; yet in 1830 the quantity raised was thirty millions, and in 1851 not less than fifty-four millions.* From 1854 downwards, we have the returns of the Mining Record Office,† which show a general tendency to expansion, though with fluctuations; the maximum having been reached in 1861, when the enormous quantity of eighty-six millions of tons was brought to the surface.

Notwithstanding these facts, however, it would be rash to assume that the experience of the past is to be a criterion of the future. We neither wish for, nor expect, an increase during the remainder of this century at all proportionate to that of the earlier half, and this view is borne out by some of the later returns. Some of our coal-fields, as has been shown, have passed their meridian, and, having expended their strength, are verging on decay. Others have attained their maximum, or nearly so; this indeed is the case with the majority. The younger coal-fields will have much of their strength absorbed in compensating for the falling-off of the older; so that in a few years the whole of our coal-producing districts will reach a stage of activity beyond which they cannot advance, but around which they may oscillate. Entertaining these views, I am inclined to place the possible maximum of production at one hundred millions of tons a year; and yet it has been shown that even with this enormous "output," there is enough coal to last for eight centuries.

* On the authority of Mr. J. Dickinson, Her Majesty's Inspector of Coal Mines.

† 'Mineral Statistics,' 1854-61.

OCEANIC TELEGRAPHY.

I. The Deep-Sea Bed of the Atlantic and its Inhabitants.

By Dr. G. C. Wallich, F.L.S.

The sounding-machine has already conducted us to the confines of an unexplored world. It has enabled us to penetrate the secret so long and so steadfastly concealed by nature beneath the waters of the ocean, by placing within our grasp the still living forms of creatures differing in no material respect from some of those inhabiting moderate depths, yet capable of sustaining existence under the extraordinary conditions known to prevail amidst the more profound abysses of the sea-bed. In short, it has taught us that our preconceived views concerning the incompatibility of these conditions with the performance of functions which are essential to life, are erroneous and demand most careful revision.

The fact, as thus stated, appears simple enough, and may, by many persons, be regarded as involving purely scientific issues. It will be our aim, however, to show that this is by no means the case; and that, whilst the interest attaching to the discovery of animal life under such circumstances is undoubtedly great, and likely to lead to valuable results in every department of Natural History, the practical bearing of this discovery on the question of Oceanic Telegraphy is of no less important a character. But in order to render ourselves intelligible, we must briefly direct attention to what was known on the subject prior to the time when it assumed its present aspect through the discovery of living star-fish procured from a depth of nearly a mile-and-a-half below the surface.

Without stopping to notice the various conjectures regarding the nature of the deep-sea bed, which had previously been hazarded, it may suffice to mention that specimens of the material of which it is composed were, for the first time, systematically obtained about ten years ago. These consisted, for the most part, of an extremely fine mud, with a large proportion of microscopic shells belonging to one of the simplest forms of animal life with which we are acquainted. Some of the shells retained a considerable portion of the gelatinous substance of which the bodies of this class of organisms is composed. But at this point the evidence failed. For whilst the fact of these organisms having been raised from vast depths was too clearly established to admit of the slightest doubt, it is manifest that they might have been drifted from shallow water by oceanic currents, or have lived near the surface of the sea, and gradually subsided to the bottom after death. Accordingly, the mere presence of the gelatinous substance of which their bodies are formed, when taken in connection with the well-known preservative power of sea-water highly charged with saline matter, affords no proof whatever of the creatures having lived in the localities from which they had been conveyed by the sounding-machine. But although the determination of the question as to whether animal life can be sustained at such depths was reserved

for a later period, these earlier soundings were not barren of highly important results; for they enabled Professor Ehrenberg, on comparison of the material obtained from the bottom with that entering into the formation of chalk, to announce the extraordinary fact, that this rock is built up, atom by atom, of shells similar to those met with in such profusion along the bed of the ocean; and further, that it must have been deposited under conditions similar to those now prevailing; thereby furnishing the clearest proof that the great forces which were in operation at the sea-bed countless ages ago, are in operation still; and will, in all probability, continue to be so through all time.

We now arrive at the period when the survey of the sea-bed received a fresh and powerful impulse from the project of establishing communication between Europe and America by means of a Telegraphic Cable. With a view to ascertain the general contour and composition of the portion of the Atlantic it was proposed to traverse, an expedition was sent by the Government of the United States, to sound from shore to shore. But unfortunately, the information elicited in the course of this survey was so vitiated by inaccuracies as to have induced the eminent officer, then in charge of the Hydrographic department at Washington, to pronounce it untrustworthy. A second expedition was accordingly equipped, under the auspices of the British Government. Of the accuracy of the depths recorded on this occasion there could be no doubt. But the intervals between the positions at which soundings were taken were so great, and the means of obtaining specimens of the bottom so imperfect, that, looking at the matter as we now do after the event, it seems impossible to regard the information elicited as in any degree adequate to meet the requirements of the enterprise for which the survey was undertaken.*

It is true these soundings, as far as they went, indicated no extreme alternations of level along the course traversed. But on the other hand, nothing could be more hazardous than to assume, because a certain degree of uniformity as to depth manifests itself at the isolated spots on which soundings were taken, that a like degree of uniformity must prevail over the wide intervening spaces. Of the spaces themselves we know literally nothing. Nevertheless on these imperfect premises was it maintained, and by many persons believed, that the entire central tract of the Atlantic, instead of being characterized by variations of level and occasional areas of naked and perhaps rugged rock, such as we might expect to encounter here and there in a region so extended, consists of a level plateau, the entire surface of which is covered by a soft stratum of mud, similar to that indicated by the earlier soundings. Now, it must be obvious to every one that, however steep a submerged declivity may be, unless the depth is ascertained at two or more consecutive points, the information elicited will be the same as if the sounding-machine had been dropped on the most perfect level. And accordingly, for aught these soundings have shown to the

* To render this statement intelligible, it may be mentioned that along 1,300 miles of the Mid-Atlantic Telegraph route, only forty-one soundings were taken, the intervals varying between 32 and 71 geographical miles.

contrary, the bed of the Atlantic may present features the most opposite to those that have been ascribed to it. But let us not be misunderstood. It is neither our intention to assert, nor do we believe, that insuperable alternations of level are likely to be encountered. We simply deprecate the hasty adoption of a view so unsubstantiated by proof, and so calculated, if erroneous, to interfere with the accomplishment of one of the most important enterprises of the day.

It should be borne in mind, that the supposed plateau does not comprise a limited area, but one extending for upwards of a thousand miles across the basin of the Atlantic. Now, there is no parallel case to this in any portion of the present dry land. And, since there is no ground for the belief that such a vast area could possibly have remained unaffected by the agencies which produce modifications in the earth's crust elsewhere; it is—to say the least of it—extremely improbable that so signal an exception should occur only along that portion of the sea-bed which has been selected as the site of the Telegraphic Cable. We say *only*, because, judging from soundings taken elsewhere, it is manifest that alternations of level are the rule rather than the exception, and that, in some cases, they are of an important kind.

But it is not necessary to have recourse to soundings, in order to prove the accuracy of this opinion. The islands that rise so abruptly in many portions of the Atlantic, if reduced somewhat in elevation, might occur over and over again within the intervals at which the depths have been recorded, and yet be completely overlooked. Their existence is known simply because they are lofty enough to appear above water. It would be an act of rashness, therefore, to assume that formations similar in their character, but of smaller size, do not occur in positions where they still remain unrecognized.

Of what then, it may be asked, does our knowledge regarding the contour and composition of the sea-bed really consist? The answer to this question is by no means unsatisfactory. Thus, it is certain that in no region of the ocean in which soundings have heretofore been attempted with adequate apparatus, is the depth so inordinate as to be beyond reach. It is equally certain that, as a general rule, the depths are moderate—that is to say, rarely exceeding 2,500 fathoms, or a trifle under three miles; that, for the most part, the bottom is composed of a soft but tenacious mud, consisting either of an admixture of organic and inorganic débris, or of one of these constituents more or less uncombined with the other; and lastly, and pre-eminently perhaps, that deep-seated currents, if they prevail at all, are exceedingly rare and too feeble to produce the slightest deleterious effect upon a submerged Telegraphic Cable. These, we venture to say, are no unsatisfactory results when weighed against the limited and imperfect nature of the opportunities that have hitherto been afforded for the exploration of the sea-bed; and so far from being of a disheartening tendency, they offer conclusive evidence that the perfection of our knowledge with regard to the conditions prevailing along any given tract of the sea-bed, falls readily within our powers, and is merely a question of time and perseverance.

It would occupy too much space were we to enter into the whole of the facts bearing on the muddy deposits, with whose presence, over a considerable area of the sea-bed, the sounding-machine has made us acquainted. But there is one point to which we must invite attention, inasmuch as its importance can hardly be overestimated, and yet, strange to say, it has heretofore been almost entirely overlooked.

In some of the deeper soundings, both on the North and Mid-Atlantic route, fragments of rocks have been brought up. How is the occurrence of these to be accounted for, and what does it betoken? The question is an intricate one, and so far as our present information goes, does not seem to admit of a perfectly satisfactory solution. This much may be said, however; that their presence on the immediate surface layer of the sea-bed, is only reconcilable with one or other of the following suppositions:—They must either have been recently dropped by some means from the superincumbent waters; have been deposited by floating ice during past periods of the earth's history; must occur in beds which were once exposed above the surface of the sea; or be drifting about the bottom through the action of currents.

Now in no case hitherto recorded have these stones been of large size—probably not larger than a hazel nut—but they present undoubted traces of attrition. Fish, as is well known, sometimes swallow small stones, and, as a matter of course, get rid of them in time; but this would not meet the requirements of the first of the above suppositions, inasmuch as it is obviously improbable that so many fish with stones in their stomachs should be moving about the ocean, as would be necessary to account for the fact; and it is still more improbable, if not absolutely impossible, that fish could have conveyed such substances from the distant shores, where they are alone obtainable. So that viewing this circumstance in conjunction with the fact, that no floating ice nowadays traverses the areas referred to, it is quite certain that the matter is inexplicable on the first supposition.

If deposited from floating ice during past periods of the Earth's history (according to the second supposition, which is by no means impossible), it follows as an inevitable consequence that the muddy deposits are local in character, and that certain areas of the sea-bed consist of bare rock; or that they are swept away by currents as fast as they are produced. We regard the first of these two views as most conformable with the evidence; for, although there is reason to believe that deep-seated currents prevail with sufficient force, in some of the shallower tracts of the Atlantic, to move the fine particles of which these deposits are for the most part composed, there is no ground whatever for supposing that they are ever powerful enough to sweep along large objects, such as the stones of which we have been speaking. It will be seen, therefore, that we are fully justified in laying stress on the possibility that extensive areas of exposed rock may occur along the basin of the Atlantic, which have hitherto escaped detection. The third and fourth suppositions are thus disposed of likewise.

But the facts just set forth involve another very important consideration, which, as supporters of no particular creed, we deem it necessary to notice. In assuring ourselves of the absence of currents as a source of danger in Oceanic Telegraphy, we no doubt gain a material point. But to some extent the gain is counterbalanced, and in this wise. Assuming that the bed of the present ocean has been subject, at some antecedent period of the world's history, to the denuding action of atmospheric and terrestrial influences, and has thus been impressed with characters similar to those we see around us on dry land (and that it has been so, there is no valid reason to doubt), whatever asperities may have marked its surface when it was first submerged, must remain stamped upon it up to the present time. The denuding action of water in a state of motion is very great; but that of water in a state of comparative quiescence, such as prevails along the sea-bed, must be extremely limited, if it operates at all. Atmospheric agencies which wear away the rugged features of one district on land and reproduce them on another, are powerless either for good or for evil at the sea-bed. And hence it is certain, that however much the muddy deposits may be constantly contributing towards the toning down of the minor inequalities, they can exercise very little effect as regards those more extensive alternations of level, the absence of which along the sea has been assumed, solely because the means heretofore adopted have been inadequate for their detection.

But let us now turn to the living tenants of these deep abysses. It has already been stated, that although the evidence of the vitality of the minute shell-covered creatures, obtained in the course of the earlier soundings, was altogether inconclusive, more recent observations have established the fact that the conditions prevailing at extreme depths are not incompatible with the maintenance of animal life. The observations in question were made at the close of 1860, during the survey of the North Atlantic route by H.M.S. 'Bulldog.' Into the details of these it would be out of place to enter at present; but the proofs they involve, may be stated in a very few words.

Thirteen living star-fishes, differing in no important particular from a species common on our own and most northern coasts, were brought up from a depth of 1,260 fathoms—or very nearly a mile and a half—at a point midway between the Southern extremity of Greenland and Rockall, and 250 miles distant from the nearest land. These star-fishes, however, cannot be said to have been captured by the sounding-machine, for they came up adhering by their spine-covered arms to the last 50 fathoms of the sounding-line, not as voluntary exiles from below, but owing to their having coiled themselves around a material from which they found it impossible afterwards to disengage themselves. Now, apart from all other evidence, the facts in connection with this particular sounding were sufficient to indicate that the star-fishes had been raised from the sea-bed itself, and had not grasped the line while floating in some stratum of water intermediate between it and the surface. But, by a singular piece of good fortune, the question as to their last resting-place admitted of definite determination on evidence that they bore along with them. To com-

prehend the value of this, it is necessary to mention that by means of a separate observation taken upon the same spot, the bottom was found to consist almost entirely of the minute shell-covered organisms already referred to; and, taking into consideration the fact that many of the shells were completely filled with the gelatinous substance of which their bodies are composed, and lastly, the fresh appearance of this substance; the probability is very great that they, in common with the star-fishes, had lived and multiplied at the bottom. But the only circumstance which ought to be accepted as direct proof of their vitality, namely, motion after reaching the surface, was wanting; as indeed it well might be, since the passage through the vertical mile and a half of water occupied nearly an hour, and the change of conditions to which the creatures became subjected, during that period, must necessarily have been very great. Nevertheless the chain of circumstantial evidence was rendered complete; for, on examining the stomachs of the star-fishes, they were found to contain the minute shelled creatures in abundance; thus clearly establishing the fact of the star-fishes having attached themselves to the sounding-line whilst it rested on the bottom, and adding the strongest confirmation to the view that the minute creatures referred to were brought up from their natural habitation.

But it was not to be expected that a fact so subversive of all preconceived notions regarding the conditions essential to the presence of animal life on the ocean would be received without the usual amount of salutary scepticism. And hence, on its being boldly announced not only that highly-organized animals had been brought up from so vast a depth, but that they actually arrived at the surface in a living state, scientific men shrugged their shoulders, and demanded the production of the most complete proofs. These proofs we submit have been produced; and they serve to show that instead of organic life being carried on in defiance of the conditions so erroneously held to be incompatible with it, the presence of some of these conditions is indispensable to its continuance. In order, however, to render intelligible the doubts that were expressed on the subject, and the precise bearing of the evidence brought forward with a view to dispel them, it is necessary to draw attention to the conditions on which the determination of the question depends.

According to the generally accepted opinion regarding the Geographical distribution and vertical limits of marine animal life, the presence of one set of conditions is essential, that of another incompatible with it. Thus we are told that a certain amount of aëration of the water, especially with reference to the quantity of oxygen gas contained in a given volume, and the previous existence of vegetable life in some shape or other, are indispensable to the maintenance of animal life; whereas the increase of pressure beyond a certain degree, and the total absence of light, determine the limit in depth beneath which, it was contended, no living being could exist.

Now, although in the present state of our knowledge, it is difficult to conceive that any animal, no matter how low in the scale, can live in default of a supply of oxygen, we are by no means called upon to

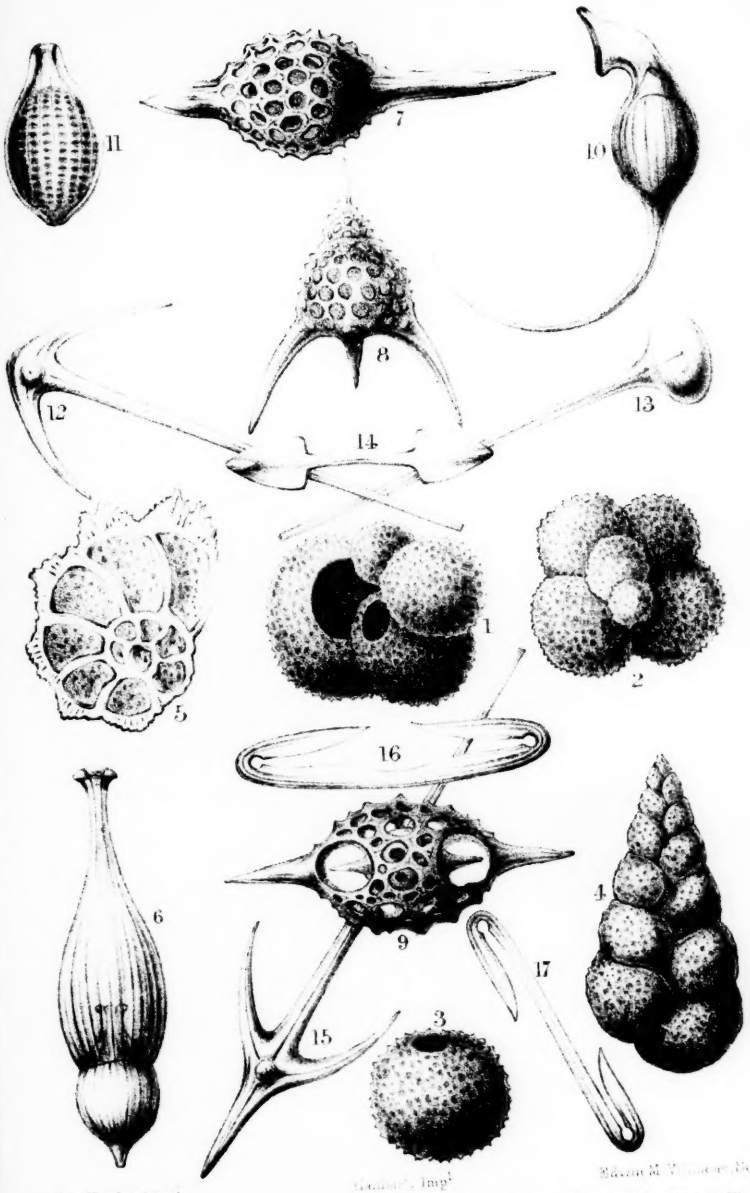
believe that this gas is in reality absent in sea-water at great depths.* From observations conducted many years ago by an eminent French experimentalist, M. Biot, it would appear that the swimming bladder of fishes contains a larger quantity of nitrogen than oxygen when they happen to have been captured near the surface; and a larger quantity of oxygen than nitrogen when brought up from a depth of a few hundred fathoms. The researches of other observers would also tend to confirm the view that the quantity of oxygen held in solution by sea-water increases rather than diminishes with the depth; and on theoretical grounds, moreover, there is reason to believe that the presence of oxygen is inseparable from the pressure which prevails at great depths.

In the case of creatures belonging to the higher order, as, for example, fish, the conditions that have been laid down are no doubt indispensable. They cannot support life beyond a comparatively moderate depth; and, as a general rule, it may be taken for granted that no living organism, demanding a supply of free air for its sustenance, or whose structure is of such a kind as to be inordinately affected by an increase of the pressure to which it is subject in shallower water, could, by any possibility, survive a single instant after descending lower than a few hundred fathoms. But there is a large class of creatures, inhabiting the ocean at ordinary depths, whose structure is so universally permeable by fluids that, assuming other conditions to be favourable and the transitions from a low to a high degree of pressure to be sufficiently gradual, it is immaterial whether the medium around them be pressed upon by one or by one hundred atmospheres. In the case of these creatures, as in that of a human being living under ordinary atmospheric pressure, it is only essential that the force should operate uniformly both within and without the body. Hence, in so far as mere pressure is concerned, there is no reason why creatures of the class referred to (and star-fishes are amongst the number) should not be able to exist at all depths.

With regard to the previous manifestation of vegetable life which is said to constitute a condition essential to the existence of animals, both terrestrial and marine, it is only desirable to point out that, were this really a law of nature, it would at once negative the assumption that animal life can be maintained at extreme depths; for, if vegetable products are indispensable for the nutrition of the animal, and no vegetable structures are capable of living in default of a certain amount of light, inasmuch as no light can possibly penetrate to the profounder abysses of the ocean, animal existence must of course be rendered impossible.

But whilst recent explorations of the sea-bed have indubitably indicated that animals can live at those vast depths, they would also seem to show that vegetable life, in any form at least in which we have heretofore detected it, is not co-existent; for whensoever vegetable structures have been found amongst the organic or inorganic matter of

* M. Pasteur, the French chemist, in his recent experiments on Ferments, has sought to show that some of the so-called Infusoria are able to exist without oxygen.



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GROUP OF CALCAREOUS & SILICEOUS ORGANISMS FROM THE DEEP SEA BED.

Figs. 1 to 6. FORAMINIFERA. Figs 7 to 9. POLYCYSTINA.

Figs. 10 & 11. SAGYNIDÆ. Figs. 12 to 17. SPONGE SPICULES.

XUM

the deposits, the peculiar condition of their soft parts has invariably been such as to indicate their having lived in shallower zones, and only descended to the bottom on life becoming extinct. It is manifest, therefore, that the law referred to, however stringently it may apply to terrestrial life, admits of exceptions in the case of marine forms. How these exceptions are provided against remains yet to be ascertained.

But, it may be asked, what are these mysterious little atoms of which so much has been said, and which play so important a part, not only in the composition of the present sea-bed, but of vast tracts of existing dry land. For the benefit of those who have not directed their attention to the subject, we append the following brief particulars and the accompanying Illustrations.

The animal, as already stated, is one of the lowest in the scale of creation. It consists of a minute particle of viscid matter, not unlike the fluid but yet granular portions of honey both as to consistence and colour, and like honey devoid of organization. Nevertheless it possesses vital contractility, and the power of altering its shape to any extent. The little mass is not naked, however, but in virtue of another vital faculty inherent in it, is able to extract calcareous matter from the water in which it lives, and re-secrete it in the form of the exquisite shells known to naturalists under the name of *Foraminifera*. In the deep-sea species to which we are particularly referring, the shells consist generally of a number of chambers ranged in more or less symmetrical order, and each communicating with the rest and with the outer world by one large aperture, and a number of minute pores studded over the entire surface. Through these, the little animal is continually projecting, and as continually retracting, delicate thread-like feelers, composed of the same substance as the rest of the body. By means of these feelers it performs the movements of which it is capable, and, in all probability, is enabled to provide itself with food. Hence it will be understood why it was stated, in a former portion of these observations, that in the absence of these movements it becomes almost impossible to determine whether the object before us is alive or dead.

But although this wonderful little creature demands special notice, owing to the share it takes in the composition of the deep-sea deposits, numberless other forms are to be met with, equally simple in their nature, but still more beautiful in their structure. And this leads us, in the last place, to inquire whether or not there is reason to apprehend danger from their attacks upon a submerged Telegraphic Cable.

On this point we can speak with confidence. If there be any source through which the abrasion of a cable, either by contact with other substances, or the attacks of creatures able to bore into its coverings and thus destroy or impair its insulation, may be obviated, it is through the gradual incrustation that these humble shell-builders are sure to form around it. Accordingly it becomes of the utmost importance to select, as far as is practicable, those areas of the sea-bed which are covered by the foraminiferous deposits, and to avoid those which are bare. Minute Annelids unquestionably exist even at the greatest depths,

and amongst these there are some capable of doing mischief. That they can penetrate gutta-percha solely by means of the boring organs with which they are provided, we altogether disbelieve. But, in most cases, there is ground for suspecting that their penetrative powers are materially aided by secretions capable of acting chemically on the substances attacked. Of the nature of the secretion, or its possible effect on caoutchouc or gutta-percha, we know nothing. But this is no reason for repudiating the possibility of an event, which if brought about only once, in the 2,000 miles of cable, would prove fatal to its working integrity. It only remains to be added, that we are no alarmists. We would neither conjure up, magnify, nor ignore danger. What we desire and believe to be indispensable, if telegraphic communication across the Atlantic is to be viewed in any other light than as a source of national chagrin, is that measures should be forthwith adopted to add to the scanty information we already possess regarding the sea-bed; under the firm conviction that whatever difficulties may present themselves, they require only to be understood to ensure their being surmounted.

II. The Atlantic Cable and its Teachings.

By William Crookes, F.R.S.

There is scarcely a question of more importance at the present day, than that of telegraphic communication with India. When these pages are before the public the line which is to connect the two hemispheres will be *en route* to its destination; and judging by the vast experience accumulated during the construction and laying of the old Atlantic line, and the invaluable evidence which on its demise was elicited at the inquest, there is every reasonable hope that the new enterprise will be successful.

A great amount of misconception prevails respecting the now defunct Atlantic cable, and pending the successful termination of the undertaking now in progress, we propose to disinter from the ponderous official documents some portions of its history which are not generally known, and, with the aid of other material now before us, to examine what is the reasonable prospect of success or failure in other similar undertakings.

The problem to be solved is comprised in a very small compass. There is not much difficulty in making a cable perfect as to its electrical conditions, and should any flaw or faulty part happen to pass the first scrutiny, skilled electricians can at once detect it. The great difficulty which now weighs like an incubus upon every large undertaking of this kind, is to submerge the rope without injury. There is now an absolute certainty of making a cable of any length perfect, but we destroy it in attempting to get it to the bottom of the sea. If the insulated wire, in as good a state as when it leaves the contractor's works, could but be transferred uninjured to the ocean's bed, it would lie there as quietly as if it were at the bottom of a well, and would last for hundreds of years.

Unfortunately, the first-laid submarine cables were attended with complete success; these precedents were used as arguments against any further investigation, and hence the hasty enterprise of the Atlantic cable, involving an expenditure of three-quarters of a million, was rushed into in the most reckless manner, and with so utter a disregard of precautions, as to seem from the first actually to invite failure.

The perfection of a cable depends upon the perfection of each individual inch of it; in this respect it is similar to a chain, which is valueless if a single link be faulty. The insulating covering of the conductor is composed of substances so delicate in texture, and laid on in such a manner as to render it extremely difficult to avoid *faults*. These are generally noticed as soon as they appear, and by taking the precaution to test the cable in definite lengths under water, they can be readily detected at any time, and their position ascertained. What is generally known as a *fault*, is a communication between the conducting wire and the water; this may be either very slight, in which case, the insulation is more or less injured, or it may be sufficient for the whole of the electricity to leak through. A small fault, which would not be of serious consequence in a short line, cannot be tolerated when the cable is of considerable length, as the powerful currents necessary to force a signal through, find out all the weak points, and eat them into fatal holes. There is another reason why faults or even weak places must not be admitted in submarine lines; it is that they are so liable to injury through lightning. In the Channel Islands' telegraph, the lightning struck the cable in Jersey, and passing under the sea along the wire for sixteen miles in the direction of Guernsey, met with a weak place, where it burnt itself through into the water, destroying the insulation.

The material of the outer covering of the cable, and the manner in which it is laid on, are matters of great importance. There must be no strain on the core, and the finished cable must have as little elasticity as possible. Many cables have been injured from a neglect of this precaution: an elastic rope will stretch four or five per cent. during deposition, and will contract when the tension is removed and the temperature is lowered by the surrounding water. The copper wire is however permanently stretched, and where the gutta-percha contracts over it, the wire occasionally knuckles through and produces a serious leakage. The outer coat of mail is almost invariably of a spiral form, which perhaps is the only kind that could be adopted, having regard to the frequent coilings and uncoilings which the rope has to go through, but such a form is very liable to kink whenever the rope is not kept in a state of tension.

The copper of which the conducting wire is now invariably made, should be selected with the greatest care. When pure it is one of the best solid conductors known; but very slight impurities, such as are almost always met with in the commercial metal, are sufficient to greatly diminish its value. Taking the conducting power of pure copper as 100, Dr. Matthiessen found that of samples of American, Australian, Russian, and Spanish copper to be respectively 92, 88,

59, and 14. Since these results have been made known, the wire is always contracted for of a certain specified conducting value per mile.

Much has been said about the deterioration of gutta-percha when exposed to the air, and the great difficulty of avoiding flaws in laying it on the wire; these evils are however greatly magnified. The rotting will not proceed under water, and even in air it may be prevented by a coat of Stockholm tar, whilst the small and unavoidable flaws are perfectly guarded against by applying several successive coatings to the wire. Other complaints brought against gutta-percha, are that it does not insulate very perfectly when warm, and also that it is liable to soften. These are reasons against unnecessary exposure of the cable to heat before its submergence, but are of no consequence when once it is laid. At the bottom of the ocean everything is in favour of its permanence. The surrounding sheath of tar tightly held in iron wires, the low temperature of the water, the preservative properties of the sea, the absence of light and air, and the enormous pressure to which it is subjected, are all elements tending to improve the lasting and insulating properties of gutta-percha.

Many of the most important facts above referred to have been ascertained since the Atlantic Cable was manufactured, but they ought to have *preceded* instead of succeeded so important an undertaking. This could have been done easily by an expenditure, trifling when compared with the amount at stake, and it would have supplied the Company with knowledge which has been purchased at three quarters of a million sterling. There was far too much haste in the preliminary stages of the undertaking. It was looked upon merely as a commercial speculation, and in order to raise the requisite funds, promises to the shareholders were most rashly made. Whilst the Company was only formed in 1856, the line was undertaken to be laid in 1857, and in order to keep faith with the public, the preliminary experiments and investigations, which ought to have occupied the highest available talent for some years, were hurried over in the most reckless manner, or were left to be completed by chance. Indeed, the most important piece of machinery in the whole affair, that for paying out the cable,—an apparatus which would have to run as smoothly as a cotton mill for every minute of the time occupied in that operation, the slightest hitch or irregularity snapping the cable, —was literally being put together for the first time as the ship was sailing to its destination, and was entrusted, untried, with its precious charge. The result may be anticipated. A stoppage in the machinery occurred, and 335 miles of cable were sacrificed at the shrine of official incompetence.

Another great mistake was to have such a rope made of any but the very strongest materials. It was intended at first that the outer covering should be of steel wire, but this could not be adopted owing to the unfortunate promise made by the directors that it should be laid in 1857. Had another year been permitted to elapse, and, instead of iron coating, had steel been employed, there is every probability that the cable would have been at work at the present day. Instead of a breaking strain of three tons it would have borne uninjured a pull

of twenty tons, enough, if requisite, to have anchored the 'Agamemnon' in the middle of the Atlantic, and to have endured without damage any imaginable vagaries of the paying-out machinery. The objections that steel cables do not coil as well as iron, and seem "all alive" from their springiness, are not of much weight, as the enormous surplus strength would enable them to bear a considerable amount of hard usage in stowing them away.

In paying out a cable much depends upon its being properly coiled. This was certainly well done in the Atlantic line, and it is doubtless to this fact that the last successful paying is to be attributed. During the whole process of paying out a kink never once occurred; in fact it uncoiled itself, for the men who were stationed in the hold to undo the lashings, and be ready in case of accident, scarcely were required to touch it once.

Few people can imagine the great mechanical difficulties to be overcome in laying a long cable. Owing to the difficulty of making the joinings properly at sea, the rope cannot be carried out in more than two portions, and there are very few ships capable of conveying the required load in the necessary manner. An electric cable is a difficult thing to coil, indeed no one, who inspects it in short lengths, would believe it capable of being coiled at all; the cable must, therefore, be laid in the hold, in as large a circle as possible, and the space occupied must be perfectly clear from cross-beams, or perpendicular supports for the deck. The cable must be placed so as to load the vessel evenly, and must be so paid out that she shall preserve an even keel, otherwise water ballast must be admitted to keep the vessel in trim. Moreover, with a long cable, the vessel employed should be a steamer of sufficient dimensions not only to contain it, but coals as well for the entire voyage, for, if stowed in a sailing vessel and towed by a steamer, the ship becomes in a heavy sea unmanageable, and in case of a hitch occurring, it is almost impossible to check her progress in time to prevent accident. A cable long enough to span the Atlantic will weigh at least 6,000 tons, and when coals must be carried, and in addition a clear space provided sufficient to enable this enormous length of cable to be coiled, it is evident that no existing vessel except the 'Great Eastern,' would be equal to the requirements of the case. The hands employed in liberating the cable coiled in the hold have a difficult task to perform even when the sea is calm and everything goes on smoothly. When at full speed the coils have to be carefully liberated, layer by layer, from the lashings and packings of wood, so as to set free only so much of the cable as is required, so as to avoid the possibility of its escaping from the guides on receiving any check. The break is a part of the apparatus which requires the most delicate handling; the strain which it puts on must be sufficient to prevent the cable from running out with too great a velocity in proportion to the speed of the vessel, whilst it must be sensitive to every pitch and roll, in order to prevent the cable from being snapped by a sudden strain. Many self-acting breaks have been proposed, but in practice nothing has been found so effectual for the regulation of the strain as constant personal superintendence. The speed at which the

paying-out vessel travels should be as uniform as possible throughout the whole voyage, and as provision must be made for contrary winds and rough weather, a large amount of surplus power is indispensable. In fair weather it is not difficult to attend to all these precautions, nothing but proper care and attention being necessary; but in stormy weather, when the vessel is tossing to such an extent that the men can scarcely stand while unlashing and freeing the cable, when the pitching of the ship throws sudden and violent strains upon the break, and when the breaksman himself can scarcely keep his feet, and can see nothing in the darkness, the difficulty in managing the apparatus properly is of no ordinary kind.

An indicator is attached to the break, which is supposed to show the strain upon it, but, owing to its inertia, such an instrument is of very little value for obviating sudden jerks. For instance, on the occasion of the first snapping of the Atlantic Cable, the indicator showed a strain of only 35 cwt., although the cable was supposed to be able to resist a strain of 60 cwt.

During the paying out of the Atlantic Cable great doubts were entertained of its permanent success, owing to the serious faults which soon became apparent. The 'Niagara' and 'Agamemnon' having met and joined their respective halves of the cable in the middle of the Atlantic, started thence and proceeded, one to Newfoundland, the other to Valencia Bay, in Ireland, electrical signals being constantly passed from one ship to the other. At one point, when nearly 400 miles had been paid from each ship, the electrical signals became very weak, and the tests applied by the electrician on board the 'Agamemnon,' showed that there was defective insulation at a very remote part of the cable. The fault then seemed to get better, and in about an hour the cable tested as usual. Three days afterwards, when about 560 miles had been paid out from each vessel, considerable irregularities were observed, the signals becoming weaker, until it was reported from the electrical cabin that they had ceased altogether. They shortly afterwards returned, and gradually improved for some hours, when they became as strong as ever. In fact, on the evening of this day (August 2), the signals from the 'Niagara' were reported to be stronger than they had been previously. Other irregularities in transmission were afterwards observed, but the general working of the cable seemed good, and on referring to the memoranda taken by the electricians at the time, we find the signals spoken of as "good" in the morning of the 3rd of August, "first rate" about the middle of the day, and "perfect" in the evening. The next day we have reports of constant signals from one ship to the other, and the memorandum "all right," is repeated several times. On the 5th of August, at 2.10 A.M., the 'Niagara' signalled that she had paid out 1,000 miles of cable, and at 3.50 A.M., the 'Agamemnon' had paid out the same quantity. At that time, intelligible signals were passing through the 2,000 miles of cable, from one end to the other, and in a few hours each ship was safely at anchor.

Thus, then, the possibility of connecting the two continents by an electric cable was proved and considering the unjustifiable haste and

disregard of necessary precautions, more than this could not be expected. Indeed, it was scarcely anticipated during the paying out, that any result whatever would be gained. The many coilings and uncoilings which the rope had undergone, had undoubtedly caused injury. The leakage at Keyham was very great, and many bad places were cut out; but as the cable was not once tested under water before its actual submergence, some imperfections necessarily escaped detection.

It soon became evident that very serious faults existed in the cable; its capability of conveying signals varied greatly, going and coming at uncertain intervals, and sometimes stopping altogether; and when to this was superadded the tedious nature of the signalling, owing to induction, it is somewhat surprising that any intelligible messages passed through its whole length. Indeed, had it not been for Professor Thompson, who, without fee or reward, threw himself heart and soul into the affair, the cable most probably would not have spoken at all.

Even when the wire worked well, the sluggishness of the current was a serious obstacle to the reading of the signals. If the 2,000-mile wire had been suspended in air, the signals from one end to the other would have been practically instantaneous; but surrounded as it was with iron and water, great retardation took place from induction, three or more seconds being required for the electric wave to pass along the whole distance. If the discharge at the one end were effected as rapidly and sharply as the charge at the other end, the time occupied in the transmission would be of no consequence, but unfortunately the discharge is always slower than the charge, and consequently a series of sharp crisp dots signalled into the wire at Valencia, would be smeared into a continuous line when they came out at Newfoundland. On this account words could only be transmitted very slowly, the highest speed actually attained being 41 words in 15 minutes. At one time, indeed, two clerks conversed at the rate of 4 words a minute, but most of these words were abbreviated or guessed at before half spelt, so that for ordinary messages, the highest attainable speed may be put down at 2½ words a minute.

On the 10th of August, the first words were sent from America to Ireland, but although the whole day was occupied in such messages as "Repeat, please," "Please send slower for the present," "How do you receive?" "Please say if you can read this," "How are signals?" "Please send something;" and the second day was occupied in similar messages and requests to "Send alphabet," and "Send V slowly," Valencia, like a coy maiden, refused to respond to these entreaties. On the third day, Valencia showed signs of thawing, and condescended to obey the request contained in the following message sent from America:—"If this received, send battery current in one direction five minutes." The next day when America signalled—"Send word Atlantic," Valencia was able to reply, "Atlantic:" (this was the first word read in America.) We then find several words from Valencia in answer to American entreaties, but during the whole of this day, America was signalling to Valencia such messages as these:—"We receive currents, but can't read you," "Can't read." "You must send slower, as some of your dots do not show on most delicate

detectors," "We get your currents, but so irregularly, that we cannot read them; will you examine your key well?" On the fifth day, Valencia thawed a little more, and actually asked America to "Send faster;" but although several long messages were sent on that day from America, only isolated words were received in reply. On the seventh day, Valencia and America seem to have arrived at a better understanding with each other, and Valencia asked, "Can you take a message?" with the warning, "You must repeat each sentence in full." Upon receiving an affirmative reply, Valencia telegraphed :— "Directors of Atlantic Telegraph Company, Great Britain, to Directors in America: Europe and America are united by telegraph. 'Glory to God in the highest; on earth peace, good-will towards men.' Repeat back faster. Queen's next." After America had telegraphed back the above message, the Queen's message was sent. This consisted of ninety-nine words, and occupied altogether sixteen hours in its transmission; many parts were repeated over and over again, and the whole message was signalled back to ensure accuracy. After this, owing to the greater delicacy in the reading instruments, and especially to Professor Thompson's beautiful reflecting galvanometer, several long messages were sent backwards and forwards; America, however, always doing the greater part of the talking. On the tenth day, very good signals came, and Valencia asked for the messages to be sent faster. The telegram respecting the collision between the 'Arabia' and 'Europe,' was sent on that day from America, and it was followed by the President's message to the Queen.

Professor Thompson was at this time constantly engaged upon experiments, and the result of these was that the cable spoke much more intelligibly, complimentary messages being sent between the directors and many public men, and several long directions on the details of working the instruments. From this time the cable seemed to improve, and on the twenty-second day the memorable Government messages were sent to America, countermanding the return of the 62nd and 39th Regiments, thereby saving to the British Government the sum of 50,000*l*.

To give our readers some idea of the difficulty experienced in forcing information through the wire, we copy verbatim the conversation which took place in reference to these despatches at the two extremities of the wire. Valencia speaks to Newfoundland at 1.30 p.m. on August 31 :—

"Can you read? We have two Government messages. Will you take? Reply direct."

Newfoundland.—"Try, but send."

Valencia.—"The Military Secretary to Commander-in-Chief, Horse Guards, London, to General Trollope, Halifax, Nova Scotia:—The Sixty-second Regiment is not to return to England."

Newfoundland.—"This received:—'The Military Secretary to Commander-in-Chief, Horse Guards, London.'"

"'Trollope,' understand, go on after 'Scotia.'"

"Is it finished after 'England?'"

Valencia.—"Yes. Now take another. Are you ready?"
Newfoundland.—"Yes, send."
Valencia.—"The Military Secretary to Commander-in-Chief, Horse Guards, to General Officer Commanding, Montreal, Canada:—The Thirty-ninth Regiment is not to return to England."
Newfoundland.—"I want you to repeat 'Canada.'"
Valencia.—"Can't read. Try Daniel's."
Newfoundland.—"Repeat from 'Canada' to 'return.'"
Valencia.—"Canada:—The Thirty-ninth Regiment is not to return."
Newfoundland.—"Understand."

The above occupied eleven hours in transmission.

On the 30th of August, Mr. Field telegraphed from America, as follows:—"Early in the morning of September 1, Please send me message that I can read at the celebration that day, and another on the 2nd that I can read at dinner that evening." Accordingly on the 1st of September, Valencia telegraphed the following message to C. W. Field, New York:—"The Directors are on their way to Valencia, to make arrangements for opening wire to public. They convey through cable to you and your fellow-citizens their hearty congratulations and good wishes, and cordially sympathize in your joyous celebration of the great international work."

Up to this time the condition of the line may be said to have undergone slight improvement. Several long and important communications had been sent through it, and it was on the eve of being formally opened for commercial purposes, when, without any ascertained cause, a collapse took place, and the Atlantic Telegraph suddenly became defunct; its death being the more ignominious when we take into account the message, in the utterance of which it expired. From this date no other sentence could be forced through, and with the exception of isolated words and signals during the month of September, all attempts to restore communication failed. As late indeed as October 20th, eight words of a sentence were spoken through the cable from Newfoundland to Valencia, but this was owing to the employment of recklessly energetic battery power, and may be looked upon as the spasmodic twitchings of a galvanized corpse, rather than healthy vitality.

Let us now try to ascertain the causes of this gigantic failure, and see whether the experience so dearly gained renders a similar undertaking likely to be reasonably successful. It must be confessed that from the first success was almost hopeless. Everything connected with the manufacture of the rope and its subsequent treatment was conducted in such a hurried and reckless manner, that few who knew all the circumstances were surprised at its failure. Before the cable was laid there was great neglect in the electrical department, and the manufacture was carried on throughout without proper supervision. At the whim of any *dilettante* experimentalist, the cable was cut through and through without hesitation, and the joints were frequently cobbled up most disgracefully. It has been estimated that there were upwards of 100 unnecessary cuts, and several imperfect joints have been exhibited, any one of which would be amply sufficient

to account for the sudden cessation and reappearance of the signalling; indeed it has been stated on good authority that skilled servants of the Gutta Percha Company who were sent to the contractor's works for the express purpose of uniting the various sections of the cable in as perfect a manner as possible, were dismissed because they made the joints too slowly, and their places were supplied by other workmen. But even then, if skilled electricians had tested the cable properly under water, they ought to have found out the locality of the defects before it was too late to remedy them. When too late it was found that a very serious fault existed about 420 miles from the coast of Ireland. It may be reasonably assumed that this was one of the imperfect joints—good enough to carry the current without betraying itself before the paying out, but—seriously weakened by the repeated coilings and uncoilings that the cable had undergone. This was broken by the strain upon it during the paying out, was temporarily brought together again when lodged on the bed of the ocean, and finally succumbed under the burning discharges from the gigantic induction coils used during some part of the short existence of the line.

Public attention is now being directed to the Persian Gulf cable, which will supply the one link wanting to connect this country with India. If the Atlantic disaster has done nothing else, it has proved the possibility of signalling through vast distances of submarine wire, whilst it has given to practical men such a fund of experience as to render a failure of the Indian line well-nigh impossible. Without going into the details of its construction we may briefly state that the copper wire possesses the highest practicable conducting value; the remote chance of holes or faulty places in the four surrounding layers of gutta-percha has been removed by an intermediate layer of Chatterton's highly insulating compound; the cable has been not only kept under water whilst at the manufacturer's works, but is carried in water-tanks on board ship to its destination, and its electrical condition is tested daily; whilst the outer coating of tarred hemp acts as a protection to the iron armour, and prevents the twisting action occasioned by the rapid passage of the wire spirally through the water during the paying out; for when the cable passes down like a screw through a nut, there is a great liability to kink.

When the cable left this island it was as electrically perfect as we can reasonably hope to get such a line in the present state of our knowledge, and the subsequent operation of paying out has been reduced to such certainty, that there is no doubt whatever about the eventual success of the enterprise. In the submarine lines hitherto laid, all the failures have been due to definite causes which can be readily guarded against. Possibly other causes of failure still remain to be traced out and surmounted, but we cannot imagine any combination of untoward circumstance which could affect the ultimate successful working of the Persian Gulf line. The greatest depth of water in which it will be laid is 60 fathoms, and should an accident happen during the paying out, causing the rope to snap, or should the electricians at either end discover leakage of insulation, or stoppage of the current, there will not be the least difficulty in fishing up and repair-

ing the damaged portion. As an instance of the certainty with which the electrical tests now employed can point out the exact locality of a fault, we may mention that in one deep-sea line a defect was detected by the instruments to exist 190 miles out at sea. A ship repaired to the spot, underran the cable, and found the calculation correct within a mile. This being mended, the electricians immediately said that their tests showed another fault about 112 miles farther. This also was found to be the case, with scarcely more error than in the former instance. The bed of the Gulf is admirably adapted for the safe preservation of a cable, being free from those great variations of depth and rocky eminences which effected the ruin of the Red Sea cable. In that instance the line was laid too tensely, and was suspended consequently in festoons between the numerous rocks. It had ample strength to bear its own weight in this position, and at first experienced no harm. Gradually however, barnacles, seaweeds, &c., found it a convenient resting-place; and in course of time they accumulated on the rope to such an extent, as to cause it to break under the additional strain. In the new undertaking, the remote possibility of such an occurrence as this will be avoided by paying out abundance of slack wherever the soundings show much undulation of the sea bottom.

The success which must attend the Persian Gulf cable, and the near approach to certainty of an equally good result in other submarine lines now in progress, ought to remove much of the financial difficulty in inaugurating another attempt to connect England with America. The first line proved the possibility of transmitting messages across the whole width of the Atlantic. This alone was worth all the expenditure incurred; and if the promoters of the new line make use only of the information which the death of the old cable elicited, the public will have no reason to regret the three quarters of a million sterling, now feeding the fishes in the cool depths of the Atlantic.

THE LATE EARTHQUAKE, AND EARTHQUAKES IN GENERAL.

By ROBERT MALLET, C.E., F.R.S.

OVER a large portion of England, people were startled from sleep, shaken by an invisible hand, in the night of the 5–6 October last (1863). A few, at once—and most persons after awhile—realized the the fact that they had experienced an Earthquake, and escaped unharmed. Amongst the tens of thousands thus aroused, who compared notes at breakfast, as to their own reception of the mysterious visitant, how few had, or have at this moment, any notion of the narrow margin during that sudden and evanescent throb, which divided their own fates, between safety and one of the most terrible forms of death—that of being buried, bruised, broken, suffocated, or perhaps burnt alive, beneath the overthrown ruin of their own hearth and home. Slight as was this shock compared with those of other lands, of the terrors

of which we delight to read—as of those of war or shipwreck—it well might startle those who felt it, if ignorance were not here bliss to nearly all of us. The pulse that careered over the face of England on that night, like the breeze that sweeps over, and waves a field of standing corn, was probably not greater in the velocity of its wave particle than is the velocity which imparts the shock one may feel by dropping on his heels from a stone-step six inches in height; but had its wave velocity been only as great as that produced by dropping in like manner from the height of a chair, it would have laid in ruins numbers of our English towns, and would have given us a sharp experience, by the loss of life and property, of the mourning and woe that are so often the lot of Earthquake countries.

Indeed, amongst the many natural gifts, referable to Geographical position and Geological structure with which Great Britain has been so lavishly endowed by Providence, none has been more important (though little recognized) in permitting our national development, than our immunity from frequent or severe Earthquakes. We may in this respect, but in a different sense from him of old, "thank God that we are not as other men are." A single shock, no greater in violence than those which occur almost monthly, within less than 2,000 miles of us (in the Mediterranean Seismic Bands)—one, namely, the velocity of whose wave particle should be no more than 12 to 15 feet per second (not so fast as we sometimes move in a carriage), would not only split and prostrate minster, spire, and column, but would leave Manchester, Liverpool, or London, mountainous heaps of brickdust, and rubbish. Terrible as are the consequences of such utter overthrows in the cities of other lands, our artificial conditions would add new horrors to the overturning of our own; for besides the conflagration that almost always succeeds the downfall, ignited by the buried household fires or lights, we should have superadded, the falling in of great sewers, with the overflow of their polluted streams amidst the ruins; the damming, more or less, of great tidal rivers like the Thames, by falling bridges; burst and spouting water mains; gas escaping and exploding in all sorts of cavities amidst these over-ground "goafs," viaducts and iron bridges brought to the ground by their own inertia, tunnels collapsed—coal and salt pits and mines ruined—roof and floor in a moment brought together—complications of horrors such as can be even but inadequately imagined. Happily there is little chance of such a catastrophe. Enough has already been ascertained, as to the distribution in space over the earth's surface of Seismic or Earthquake energy, to admit of our affirming the extreme improbability of the occurrence of any *great* Earthquake in the British Islands; but there is no physical reason why such an event might not occur to-morrow, and it is certain also that the Seismic Bands, *i. e.* the great ribbon-like spaces of maximum Earthquake energy, distributed over the surface of our earth, and which may be seen laid down upon the Seismic mercator of the world, in the British Association Earthquake Catalogue,* are given to wander, and that we have perilously bad neigh-

* 28th Report, 1858.

bours not so far away to the north and south of us, so that a time may arrive, when some remote posterity of our own may become partakers in, if not successors to, their misfortunes. But although our country is thus happily placed in one of the quieter havens of this heaving world (upon the surface of which not a day passes without an Earthquake somewhere, nor any eight consecutive months without one great enough to prostrate buildings over thousands of square miles), and is so circumstanced as never to be very *violently* shaken, yet we *are* shaken much more frequently than people generallyimagine; and now and then, as on the late occasion, the shock is sufficiently severe to be of a very awakening character.

Since the 11th century, there are upon record as occurring in the British Islands, including the Hebrides, nearly 240 Earthquakes.

Statistics have been tabulated which indicate the probability that up to the end of the 17th century not more than one-twelfth of the Earthquakes that occurred in Great Britain were recorded at all, nor more than one-half, up to the end of the 18th century. And at the present moment, there is good ground to conclude that about two Earthquakes per week shake the soil of England, Scotland, or Ireland, without counting minute and continually repeated vibratory jars, such as those long remarked at Comrie in Scotland. Now and then, some of these British shocks are not quite to be despised; for example, on the 13th of August, 1816, an Earthquake, that extended with violence over more than 100 square miles of Scotland, shook down part, and twisted upon its base the whole of the spire of the church of Aberdeen. On March 17th, 1843, an Earthquake, great enough to damage buildings, occurred in the North of England, and reached from Northumberland down to Flintshire, and from the Isle of Man to beyond Cheshire; and no longer ago than on the 9th November, 1852, a shock which threw down strong walls at Shrewsbury, extended over the British Islands from Dumbarton nearly to Dartmoor, in Devon—and from Enniskillen, in Ireland, to Gainsboro' in Lincolnshire.

Nothing was so remarkable in the mass of letters from Correspondents as to the late Earthquake (of October) with which 'The Times' and other Papers were for a few days afterwards filled, as the dense ignorance that prevails amongst all classes as to the nature of these phenomena, and of the circumstances that it is desirable to observe with respect to them.

One writer's letter contains literally but two facts, that "he felt something" which he thought must have been an Earthquake—and that "he got up, and immediately lighted a candle,"—he might have added, that in this case he did not put it under a bushel! The pseudo-scientific "communications" chiefly record the exact state of Barometer and Thermometer at the moment of shock; facts now known to be nearly as irrelevant as the price of Consols the day before. Nor is this ignorance confined to the more "ignoble vulgar," for a professed Meteorologist, for the benefit of the public at large, prints in 'The Times' a string of inquiries to which he demands answers, but which point to nothing so clearly as the writer's ignorance of the subject that he meddled with, and which he seems to think is still, as in the venerable

days of Aristotle, a branch of Meteorology; at the same time we happen to know that that Journal declined to give publicity to a carefully drawn up series of inquiries prepared for it by a competent person.

The fact is that Seismology—which has only become a science since 1846, and has since advanced with very rapid strides—has as yet not become diffused at all widely, even amongst the proper brotherhood of Science, and no attempt has been made to popularize it for the less informed reader. It occupies just now about the same relative position that Ice Theories did in 1837, when at the Liverpool Meeting of the British Association, the very first Paper that appeared in English on the Motion of Glaciers was read (on sufferance) in the Geological section; the President observing that, "as the topmost and most recent of all deposits, Ice might certainly be conceived as having *something* to do with Geology;" but no one then saw any importance, or great Cosmical relations, in the subject that since has engaged so many minds, and been shown to play so important a part in the terrestrial machine, and which, having passed into popular hands, is now being "run away with" by some Geologists, who attribute to its past or present agency many gigantic tasks that, tested by only a little exact science, would prove to be impossible. No doubt something of a like fate is in store for Seismology. Those—the few—who will master the preliminary science absolutely necessary to understand and make use of it, will find in it the key to some of the greatest, and hitherto amongst the most obscure, problems of Physical Geology. Those who will be content with scraps of knowledge, or with being told results, like children, will be amused; and, in proportion as they know more, will they be better amused, with Earthquake stories. But though they will then to some extent comprehend, they can never make for themselves real advances into the unknown. On the contrary (as with many Glacialists in relation to Geology), they may oftener, if they make the attempt, "darken counsel by words without knowledge;" for the half knowledge of ingenious men is always "the Philosophy of the unconditioned." But although this is peculiarly the popular career of such parts of science as seize upon the imagination by the grandeur of the phenomena they discuss, and admit of a smattering of their reasonings being attained without great mental effort,—still it is well, here as everywhere, that those who actually scaled the rugged precipice of science, when they have reached a firm foothold upon a new or higher ledge, should turn round and announce to those that labour in the plain, the wider and nobler horizon of nature they have commanded.

It is good, therefore, that Science (worthily so called) should, as far as possible, utter her voice intelligibly to all. Let us humbly try to do this in part for the new-born Science of Seismology; but we must begin at the beginning, albeit we may not in this paper reach the end. And first, let us understand what we are speaking about. What is an Earthquake? Our readers are confident that they can answer *that* inquiry. There are some who have read, many who have talked of them, and some even who have felt their effects. But what *are* these effects? and the cause—what is it? Let us mention one or two things which an Earthquake is *not*. It is never "one of the means by

which permanent geologic elevations of the land are produced," though too often confounded with these in all sorts of geological "systems," and *ex cathedrâ* utterances. Nor is it "the reaction of the interior of a planet upon its exterior," for that, oracular as it sounded from the lips of a Humboldt, is, in fact, to say nothing.

What, then, *is* an Earthquake? *It is the transit of a wave or waves of elastic compression in any direction, from vertically upwards to horizontally in any azimuth, through the substance and surface of the Earth, from any centre of impulse, or from more than one; and which may be attended with sound and tidal waves, dependent upon the impulse, and upon circumstances of position as to sea and land.*

To understand the definition we must have a clear notion of what a wave is. We will return to that true threshold of Seismology, but first let us take a very brief glance at the history of our subject. This is twofold: that of the facts, or reputed facts, as found in innumerable Earthquake narratives, and that of human opinion, from the dawn of knowledge downwards, as to these, in referring them to causes.

The supposed first cradle of our race, or at least of that great branch of it from which we ourselves, and almost all our knowledge, have come, was situated in regions that during all history, as now, have been greatly disturbed by Earthquakes, which thus very early engaged the minds of the more observant of men. Nothing, not even thunder and lightning, amongst natural phenomena can have so impressed the imagination of early peoples, as did these suddenly felt shakings, by a terrible and unknown power inhabiting the unseen depths of the Earth, nor more imperatively stimulated to the discovery of some cause for them.

The genius of the old nations of the East, that always "sought after a sign," or for a final cause, was and is satisfied with a myth. When Brahma turned sides, there was an Earthquake, or when the Tortoise, on which the world rests, stirred his flippers, there was the like result; and this sort travelled westwards, moulding the earlier than Homeric Mythology of the days when Greece was young, and showing itself in the mysterious power of the Trident of Neptune, Σεισιχθονος ἐννοσίγαιος. But the Greeks "desired wisdom," and only missed it as to deciphering nature, because they started from archetype creations of the mind, and not from inductive observation.

There was plenty of such philosophizing on Earthquakes amongst them. There were three theories before the days of Aristotle: that of Anaximenes, the Milesian; of Anaxagoras of Klasomene; and of Democritus of Abdera, in order of time. Aristotle himself wrote largely and learnedly in the books περι Μετεωρολογικων, and περι Κόσμου. He had remarked and classified, with his accustomed comprehensiveness, the different sorts of shocks by their sensible effects, dividing all into, ἐπικλίνται, which strike the earth's surface at an acute angle; βράσται, those that come right up (vertically), and sink down again, like a boiling spring or pot; χασματίαι, those that leave hollows after their departure; ῥῆκται, those which break forth with eruption of wind, stones, mud, &c. Those which with one great push overturn everything are ωσται, and those, that with much shaking to and fro, and up and

down, replace the objects they have displaced, and are of the nature of tremors, are παλματίαι.

The first, the second, and the two last, are clear, and almost exactly expressive of the sensible differences of Earthquake shocks: but in the two between, Aristotle either classes Volcanic Eruptions with Earthquakes as all parts of one common train of events—or confounds the shock with its consequences, *i. e.* the Earthquake with its secondary effects. Beyond the proof which this classification affords, that nearly two thousand five hundred years ago, Earthquakes were much the same as they are now, no man can learn anything from the disquisitions of Aristotle.

Partly from the Greek being in these passages in many places corrupt, but far more from the fact that the Greeks had no distinct notions as to those forces of matter we call "molecular," nor yet any clear metaphysics, an abuse of words is found in their Physical writings which often renders them almost unintelligible: πνεῦμα is in some sort the cause of all earthquakes, says Aristotle; but whether by the word, he meant simply the winds, or some intangible imponderable force or agent present in the earth and above it, acting upon the winds, and acted on by them, though not the winds themselves, and giving rise to Earthquakes and Volcanoes, it is impossible to determine. The word πνεῦμα was used to express pure spirit, and the wind, as well as condensable vapours, indifferently and alike, by the vulgar, and by the philosopher. Thus in John's Gospel, cap. iii. v. 8, this word occurs twice in the same verse, and is translated wind first, and spirit afterwards in our version.

The views of the great and philosophic Seneca are far more distinct and important. What Humboldt wrote, was true at the time, and the 'Questiones Naturales' contain the germ of almost everything that has been advanced in modern times as to Volcanic action in its larger sense.

But we must hurry away from classic days, leaving Pliny without notice, and pass on and over the centuries of the so-called dark ages, and of the revival of knowledge, remarking only that in the fifteenth, sixteenth, and seventeenth centuries, innumerable pamphlets and books were published, most of them recording with a grand *gobemouche* credulity, all sorts of signs and wonders, and straightway founding a theory thereon. In the seventeenth century, these usually "improved the occasion" by pointing out that the particular Earthquake was a special judgment on some unfriendly nation or obnoxious creed. The crudest and wildest hypotheses were set forth, and more or less accepted to account for the production of the shock. Thus it was due to *solutio continui* in the parts of the earth, to a sudden penning in of the subterraneous fires, to sulphureous and bituminous blasts, or, as Dr. Stukely was of opinion, to the play of lightning and thunder underground in manner like to that wherein they appear in our firmament. In nearly all these, Earthquakes and Eruptions are impartially jumbled. It is only within a very short time, that a few men in Europe have come to see, that while VULCANICITY is a word that may properly express the community as to causation that exists between

Earthquakes and Volcanoes, yet that these must be treated and investigated up to a certain point as distinct, and that SEISMOLOGY shall express the system of doctrines of the former, and VULCANOLOGY that of the latter.

There are a few bright points of observant thought to be found amidst all this "old world" muddle, however.

Fromondi, who wrote, in 1525, six books on Meteorology, and devotes the fourth to Earthquakes, refers to the explosion of the great Fire Ship, by which the beleagured Antwerpers blew up the Duke of Parma's bridge over the Scheldt, of which Mottley has given so spirit-stirring an account in his 'History of the Revolt of the Netherlands.' Fromondi remarks, that the blow of its explosion was felt almost all over Holland; and he seizes upon the analogy between the effects and those of Earthquakes; but he soon loses the train of thought that had thus so well broken cover.

Maggio, of Bologna, in 1571, was the first who made any attempt to collect and classify into eleven, the signs or presages of Earthquakes, not with much light, it must be confessed, as he put Eclipses and Comets amongst "the eleven."

Then, just about a century later, came Travagini, to whom belongs the credit of the first attempt to found a Physical Theory of Earthquake movements, and whose disquisitions present a notable example of how a man may go coasting along very near to a great truth, and yet never touch it.

He had experienced a horrible Earthquake in 1667 at Ragusa—seismically a very ugly region, being that where the great seismic band which stretching away westward from Varna and Constantinople along the Balkan, crosses the Adriatic,* and joins on to the great Italian band at Gargano and Melfi, and a place still subject to frequent and violent disturbance.

That the shock was due to some kind of impulse or blow, and that the force was in some sort dispersive, is all of truth that can be said to have been seen clearly by Travagini, though he was close to a great deal more.

Hooke, in 1690, delivered his 'Discourses of Earthquakes,' before the Royal Society. These Lectures, though called so, are, in fact, a diffuse sort of system of Physical Geology, and full of suggestive thoughts; but Hooke throughout loses sight of what an Earthquake really is, and confounds all descriptions and sources and degrees of elevatory forces and their effects, with the transient action and secondary effects of Earthquakes properly defined. These Lectures have been the mine from which numberless later Geological authors have more or less consciously drawn, and while they are a repertory of curious and often valuable thought and information, they have done great mischief in being one of the main causes of the same confusion of ideas between the effects of Land Elevation, and those of Earthquake, which is not even yet cleared out of Geological systematic authors.

In 1760, the Rev. John Mitchell, Fellow of Queen's, Cambridge,

* See Map D, 'Report to Royal Society on Neapolitan Earthquakes of 1857.'

produced a most remarkable paper on Earthquakes to the Royal Society, printed in the 'Philosophical Transactions,' vol. li.—attention being then powerfully directed to the subject by the recent terrible shock that had destroyed Lisbon.

He shows a wonderfully clear conception, for his time, of the general configuration and structure of the superficial parts (or crust as it is the fashion to call it) of the Earth, and of the relations between Volcanoes and Earthquakes. Both, he supposes, are due to vapour of high tension almost instantly generated by contact of water with incandescent rock, deep in the earth. Misled, however, by his conception of the universality of horizontally disposed strata, and of a nucleus of liquid lava universally beneath them, he goes at last hopelessly wrong, by supposing that Earthquake-shock consists in a liquid wave of translation produced in the lava sea beneath, which forces, as it travels, the flexible covering of stratified material overhead to undulate along with it, just as "a large carpet spread upon a floor, if it be raised at one edge, and suddenly brought down again—the air under it by this means propelled, will pass along until it escapes at the opposite side, raising the cloth in a wave all the way it goes." This paper though vitiated throughout by this leading fallacy as to the nature of the Earthquake wave, was a most meritorious performance, and had important effects (though little specifically noticed), in moulding the thoughts of the earlier schools of Geology.

Bertrand, Bouguer, Ulloa, Dolomieu, Grimaldi, Hamilton, and the Neapolitan Royal Commissioners, accumulated a mass of facts (and, let us add, of fictions) of Earthquakes, in the last and beginning of this century.

Humboldt added to the facts in his Personal Narrative, &c.; but nowhere, not even in 'Cosmos,' does he show that he had any clear notion of what is the nature of Earthquake motion—or how produced. In 1835, the Comte Bylandt de Palstercamp, in an extremely curious though wild and imaginative work, "La Théorie des Volcans," attempts to build up a sort of Cosmogony from considerations of the relations and reactions on our planet, of light, heat, electricity, &c., &c.—from these come Volcanoes, and from the latter Earthquakes. Truth and quasi-truth are wildly and incoherently mixed in his book. Shocks or blows produced by and transmitted *through cavities*, lifted up and down by sudden filling or emptying of aëriform fluids, form Bylandt's shock,—and starting from the following extraordinary propositions, "les effets des tremblements de terre sont toujours contradictoires aux causes qui les produisent et dirigés dans le sens inverse," —"l'effet sera celui d'un pendule, c'est-à-dire contradictore entre les deux extrémités," he arrives at the *true* conclusion, that bodies overthrown at opposite sides of a seismic focus will all fall *towards* it, but in *opposite* directions to the shock and to each other. We now know that this is only true if the bodies fall in the first semiphase of the wave. Had Bylandt followed this out, and curbed his tendency to mysticism, he would in all probability have been the creator of Seismology,—the true discoverer of Earthquake dynamics—as it was, he missed the prize.

Between 1820 and 1841, Von Hoff, Kries, Hoffmann, and one or two others, had laboriously collected and digested into order a large mass of facts, or reputed facts, of earthquakes, and to the first belongs the credit of having, in a masterly discussion,* shown what are the relations (so far as then known) between Meteorological and Earthquake Phenomena—and pointed out, that all the supposed meteorological presages were devoid of reality, and that Earthquakes belong to Physics and Geology and not to Meteorology.

But none of these men made the slightest advance towards a physical theory of Earthquake *motions*. The only true *hint* even, that was to be found before 1846, as to the true nature of the Earthquake motion, is found in a paper on Volcanoes, by Gay Lussac, in the 'Ann. de Chim.,' vol. xxii. p. 429, who quotes from Dr. Young's Lectures, and concurs in his opinion, that "Earthquakes were of the nature of vibrations in solids." Even Darwin—who of all men had had the finest opportunity of seeing the effects of Earthquake on the most extensive scale in South America—rendered no better account of the then accepted Vorticose displacement of objects, than by asking, "Might it not be caused by a tendency in each stone to arrange itself in some particular position with respect to the lines of vibration, in a manner somewhat similar to pins on a sheet of paper when shaken?"

He, too, like Parish, had recorded the circumstances of the great sea-waves that roll in, after South American and other Earthquakes, but neither rendered any solution of the facts. Nor was an attempt made by anyone, as yet, to connect these sea-waves and the sounds heard in great Earthquakes with the other parts of the phemomena.

A considerable advance had been made in a branch of science apparently remote enough from Earthquakes, which, however, greatly prepared the way for solving one part of their true history. The brothers Weber, in Germany, and Scott Russell after them, in England, had experimentally developed the science of certain classes of liquid waves; and the latter had, in 1844, shown the laws of propagation of one class of these, *viz.* waves of translation.

In February, 1846, a paper was read to the Royal Irish Academy, and then published in its Transactions, vol. xxi. part 1, "On the Dynamics of Earthquakes," which (we quote the words of the President, Dr. Chas. Graves, on presenting the Cunningham medal) fixed upon an immutable basis the real nature of Earthquake phenomena, and, for the first time, showed that the three great classes of phenomena —1, Shocks; 2, Sounds; 3, Great Sea Waves—were all reducible to a common origin, and formed parts of a connected train, and were explicable upon admitted laws. This paper also, for the first time, explained the true nature of the movements that had been called "vorticose," and viewed as proofs of circular movements, by showing that they were the result of rectilinear motions.

It also pointed out the important uses that might be made of Earthquakes, as instruments of cosmical research, enabling us not only to discover the depth beneath the surface of the origin of these shocks, and hence of volcanic foci, but ultimately of ascertaining the nature,

* Geschichte der natürlichen Veränderungen der Erdoberfläche.

as well as the temperature, of the formations within our earth, to a depth far more profound than can be reached by any other mode of investigation, or directly ever reached at all, and that by its means, we may acquire some knowledge of the formations constituting the beds, or situated even far beneath the beds, of the great oceans. These are, in fact, the great aims of Seismology, for the investigation of Earthquakes is only a means to an end.

This paper drew the attention of physicists and geologists, in a prominent manner, to the subject of Earthquakes, and was followed by several reports drawn up by desire of the British Association, and published in its volumes; and also by the laborious task completed in 1858, of drawing up and discussing the 'British Association Earthquake Catalogue.' For this large body of seismic statistics, embracing all historic time and the whole earth's surface, and numbering more than 6,000 Earthquakes, the groundwork had been laid by the immense and valued labours in the same direction of Von Hoff, and of M. Perrey of the Faculty of Sciences of Dijon, whose life has been devoted to this branch of the subject, and whose labours are still continued with the enthusiasm and success of his early youth.

Since 1846, the experimental method has been brought to bear upon the subject; and the observations made on natural shocks have been compared with those of Earthquakes artificially produced. And now Seismology has taken an acknowledged place as an important and productive branch of Cosmical Physics, and already some able men in different quarters of Europe are pursuing its study. Amongst those who have most, and most recently, advanced our knowledge, are Haughton, Favre, Schmidt Jeittelles, Otto Wolger, and Kluge. But we have now brought the history of discovery in Seismology to such a point, that its further development will best merge into the remarks to follow, upon the doctrines and facts of the Science itself.

Recurring now to the definition already given of an Earthquake, we will clear our ideas as to what it means. The shock is produced by a *wave of elastic compression* passing through some portion of the substance of our earth. Elasticity is that property in matter which tends to the restoration of *figure* in solids, and of *volume* in liquids and gases, when altered by an extraneous force; and every different substance has its own co-efficient (or measure) of elasticity of volume (cubic elasticity), and of elasticity of form (linear elasticity).

In common parlance, it is often confounded with flexibility. Thus, when people praise the springs of an easy-going carriage by saying, "they are so elastic," they mean they are so flexible. Elasticity and flexibility are, in fact, opposites in some respects. A perfectly elastic solid is one that, after forcible alteration of figure completely restores itself; if perfectly flexible, it would not restore itself at all, and might be bent to any extent without disruption. No such bodies exist in nature. All terrestrial materials present variable combinations of elasticity and flexibility, neither being perfect. Thus, Glass, Ivory, Agate, and Hard Steel are highly elastic bodies, but very slightly flexible. They break, as we all know, if but slightly bent, or

when struck sharply a blow which bends them suddenly, but they almost perfectly resume their forms after being released from an inflecting force.

On the other hand, India-rubber, Animal Jelly, and Whalebone, possess a wide range, both of flexibility and of elasticity. They recover their forms after great distortion, but not so perfectly as more rigid bodies. The *elastic limit*—that is, the extent to which their particles may be relatively displaced without fracture or other permanent alteration, is much greater in these latter, than in the former class of bodies.

But we find also bodies which, like dough, or temperered potter's clay, are extremely flexible, and exhibit hardly any tendency to resume their forms when these have been forcibly altered.

All these are solids, *i. e.* more or less rigid bodies, but liquids and gases are also elastic; liquids do but very slightly—gases not at all—resist change of figure, but they powerfully resist change of volume; and when this is altered by compression, it is restored by elasticity. Thus a cannon-shot that strikes the surface of the sea rises and ricochets in virtue of its own elasticity and that of the water, from which it rebounds much farther than from a bed of solid clay or of sand; but the range of the elasticity in volume, of liquids, is extremely small—so little, that if the weight of our atmosphere pressing upon the ocean were doubled, it would only squeeze about every million and forty-five cubic yards of water into a million. Gases, on the contrary, as we all know, are largely compressible, and perfectly restore themselves to their original volume; of this the air-gun affords an instance familiar to everyone.

Solid bodies may be deformed *by flexure*, as when a carriage-spring is bent; by *extension*, as when we pull a cord or wire endwise; or by *compression*, as when a load is laid on the summit of a column; or any combination of these may occur by the application of partial forces to their forms. But further, solids may be either homogeneous or heterogeneous, made up of different particles, or of particles having different elasticities in different directions. Thus, certain crystals have different elastic co-efficients in three different axes; and pseudo-crystalline bodies, such as the laminated slate of North Wales, or closely stratified rocks, have very different degrees of elasticity parallel to and transverse to the lamina, or to the strata, respectively.

It is in virtue of this restorative force of elasticity, that whenever a blow or pressure of any sort is *suddenly* applied, or a previously applied, steady or slowly variable force, is *suddenly* increased upon or relaxed from, any material substance, then a *pulse* or *wave* of force, originated by such an *impulse*, is transmitted through the material acted on, in all directions from *the origin* or *centre of impulse*, or in such directions as the limits of the material permit. The transfer through the material, or the *transit* of such an elastic wave, is merely the continuous forward movement of the original change in the relative positions of the particles of part of the elastic mass produced by the extraneous force or blow—a relative displacement and

replacement of those particles within a determinate volume of the material, transferred through and affecting in succession, the whole mass.

The shaking of the ground by the rolling of carriages, beating their wheels upon the paving-stones in the streets of cities, and the still more perceptible rocking of the ground beneath our feet as we stand near a heavy railway train at speed, are examples of such waves in solids.

The ordinary sounds we hear, are examples of like waves in air; and the noise of the grating and rolling pebbles moved by the waves as they approach the shore on which we stand, is an instance of such waves, transmitted from the mutually struck pebbles to the water, and through the water to the air, by which it reaches our hearing organs. While the shock or jar felt in a boat floating at some distance from a blast exploded at the bottom of the sea, is a case of such an elastic wave, originated by the blow of the powder, and transmitted directly to and through the water and the boat, to our bodies.

Now the velocity with which such a wave-form travels, varies in different materials, and if these be homogeneous, depends for any given substance, principally upon its specific degree of elasticity—technically called its *elastic modulus*, and upon its *density*, upon which its mass and inertia are dependent in a given volume. The rate at which the *wave-form*, *i.e.* the whole group of displacing and replacing particles in simultaneous movement, is transmitted in any particular substance, is called its *transit period*.

This period is *constant* (always the same) for the same material, under the same conditions as to temperature, molecular state, &c., and for small originating impulses is irrespective of the amount or kind of the original impulse which produced the wave. Experiments conducted within a few years past at Holyhead, as to the time that the wave or shock, transmitted through the Quartz and Slate Rocks there, to traverse a measured mile of rock, from the moment of production by certain of the explosions of the great mines, employed in the adjacent Government Quarries, which vary from less than a ton up to six or seven tons of powder fired at once, appear to indicate that in elastic waves of this great magnitude and transmitted through heterogeneous material, *i. e.* laminated, contorted, and shattered rocks of various degrees of hardness, density, and elasticity; the transit period is not independent of the amount of the original impulse, but that the larger this is—and the greater consequently the original magnitude of the wave—the less (in some ratio) is the time of the transit period; in other words, the faster the wave travels.

In air, the transfer of this elastic wave, which is identical with that of *sound*, has a velocity of about 1,140 feet per second. In water, the transit period is about 4,700 feet per second; and in hard crystallized rocks, such as porphyry or granite, if they were perfectly solid and homogeneous, it would be from 5,000 to 10,000, while in iron and steel it reaches 11,000 or 12,000 feet per second. An enormous retardation of this transit velocity occurs however when the material through which the wave passes is heterogeneous, broken up and

shattered. When first it was pointed out that an Earthquake shock was an elastic wave, it appeared, upon physical grounds, that the rate at which the shock having reached one place on the earth's surface, would pass on to another beyond, must be something nearly as great as that theoretically due to the elasticity and density of the rocks beneath, that is to say, often as much as 8,000 or 10,000 feet per second. This was submitted to experiment; granite rock, highly elastic and dense, ought to transmit a shock wave nearly as fast as any rocky or other material forming part of our globe, and wet sand ought to transmit it almost at the extreme limit of slowness.

More than a mile of wet uniform sand was measured carefully upon the shore of Killiney Bay, in Ireland, and several hundred feet in the granite of Dalkey Island adjacent. At one end of each of these ranges, respectively, small Earthquakes were made by exploding galvanically, casks of gunpowder buried in the sand, and blasts sunk in large cylindrical holes sprung in the granite, special means being devised for determining the time of transit, and accurate enough to measure time to less than the five-thousandth of a second; the time-measuring apparatus being set in motion, and stopped by the same galvanic apparatus that fired the powder a mile or more away. An instrument, called a Seismoscope, was also devised and employed, by which the arrival of the wave of impulse transmitted from the powder exploded at the remote end, should be rendered visible to the eye, through the disturbance of a telescopic image, reflected in the liquid mirror of a small trough full of quicksilver, which was caused to undulate and flicker by the momentary tremor of the ground beneath it. The sensibility of this instrument was so great that a horse trotting on the sand half-a-mile away was visibly seen to shake the ground, and a stamp of the foot or tap of a hammer on a large stone several hundred feet away, produced visible disturbance. This instrument was also employed at Holyhead.

The results of these experiments caused some surprise amongst physical philosophers, for in place of the enormous rates of transit that were expected, it was ascertained that the mean rates of wave propagation were only as follows in the respective media, *viz.*:

In the most solid Granite	1664·574	feet	per second.
In shattered-like Granite	1306·425	„	„
In contorted and stratified Rock (Quartz and Slate)	1088·559	„	„
In wet sand	824·915	„	„

The retardation is due to the discontinuity of the rocks, the mass of every known rock being broken up by joints and fissures, at each of which there is a loss of *vis viva*, and a loss of *time* in the transmission of the wave. The accuracy of these results, at first received with some just reserve, has since been amply confirmed by observations and calculations of the actual transit periods of Natural Earthquake waves, occurring in the Rhine Provinces, Hungary, and Southern Italy, which are found closely to co-ordinate with those of experiment.

It was ascertained that in the contorted heterogeneous and shattered rocks of Holyhead, no less than *seven-eighths* of the total theoretic

velocity of transit due to the elasticity of the rocks, which was also experimentally obtained, was extinguished thus by their want of continuity, &c.

Now, from these different rates of wave transit in diverse materials, it results that if an impulse be given at a single point, it may be perceptible several times in succession by a person so situated as to receive it through different media.

Let, for example, one stand near a line of railway, and a heavy blow be delivered upon the iron rail; it will be *heard* first, through the iron rail; almost directly afterwards a second sound will be heard through the air; and almost at the same time the person will *feel* the pulse of the blow reach his feet through the ground. While, if another person had his head immersed in the water filling a side drain along the line, he would have heard the sound through the liquid at a moment different from the arrival of any of the other waves.

Such waves, only on a larger scale, constitute an Earthquake shock.

An originating *impulse* (something of the *nature of a blow*, or *having the effects of one*) there must be for every shock, but we are not here concerned with the source from which that impulse may be produced. It may be an explosive production or condensation of high-pressure steam in heated cavities, deep beneath the surface, or *sudden* increase or decrease of its tension, or sudden fracture or fall, or forcing up or down or against each other of great rocky masses, or if (in near propinquity to active volcanoes), it may be any of their throbs or throes, or explosive ejections, or the recoil from these; it matters not as respects the physical theory of Earthquake-motion, and the explanation this renders of Earthquake-phenomena, what or which or whether any of these be the cause of the blow, so long as some sort of impulse be given, and the seat of this be more or less deep beneath the earth.

Then in all directions outwards from this centre of impulse, there will be transmitted an elastic wave. The form of the wave, if originated at one point, would be that of a spherical shell concentric with the centre of impulse, if the medium were quite homogeneous; but in nature, the wave assumes ellipsoidal and various other more complex forms, and rapidly gets broken up into smaller and still more complex waves, by dispersion, by interference, refraction and reflection, in consequence of the shattered and varying nature of all the superficial formations through which it is transmitted.

The wave starts from the origin with one normal and two transversal vibrations, *i. e.* every particle vibrates not only to and fro, in the radial direction from the centre, but also at right angles to this, in two directions at once. The former is the larger vibration and the more important to attend to, so that we may often, in investigating Earthquake-phenomena, altogether pass over the transversals. These vibrations constitute the proper motion of the wave as contradistinguished from its motion in transit.

A plumb line passing from above the surface of the earth and through the centre of impulse is called *The Seismic Vertical*. The wave or shock passing outwards from this centre, reaches the earth's

surface vertically, and soonest in this Vertical, which is the shortest distance between any point below and the surface, and here it only produces (neglecting transversals) a rapid movement up and down. The surface of the ground actually rises and sinks again to its previous place, with great rapidity, and through a range that may be several inches or perhaps feet, dependent on how great and how near the blow is given below, and what is the intervening material.

For all points around the Seismic Vertical, the wave emerges at slopes, called *emergent angles*, which become more and more nearly horizontal as the distance on the surface is greater. The spherical or quasi-spherical shell wave-form at any given distance outwards when cut by the earth's surface, intersects it as a closed curve, more or less circular, elliptic, or oval, and the crest, so to say, of this surface-wave, called a *coseismal line*, because all bodies situated in it are shaken at the same instant, travels along the surface of the earth with a real, though not large, and with a constantly diminishing *undulation*, like a roller at sea, constantly enlarging the curvilinear area within it; and as it passes outward, objects in succession are disturbed or overthrown, *not by the transit of the wave-form, but by the wave itself*, that is, by the movement of the particles in motion in the wave.

There is a certain distance outward upon the earth's surface, all round the *Seismic Vertical*, at which it may be proved that the overthrowing power of the shock is a maximum, greater than anywhere, within or without it—*within*, because there the *direction* of normal movement in the wave is more nearly vertical, and hence less calculated to upset objects *standing* on the ground—and *without*, because the further the shock has travelled away from the Seismic vertical, the more its power (to speak loosely) has decayed. This is the *Meizoseismal circle or curve*. The angle made with the Seismic vertical by a line drawn from any point in this curve at the surface down to the centre of impulse, is for the same conditions constant.

If the impulse or blow has been accompanied by rending or fracture, or the striking or grinding together of hard or rocky masses, or by the rush of vapours or gases, then the *wave of shock* will be accompanied by *waves of sound*. But these latter may or may not travel just at the same rate, or by quite the same wave-paths to the ear of a person upon the surface, as does that of the shock which he feels. Hence there may be Earthquake shocks, with or without sounds, and the shock may be perceived before any sound is heard, or the sounds may precede and herald the shock, as the awful "*bramidos*" generally do the Earthquakes of Mexico.

But to hearers remote from the Seismic vertical, the sounds, if any, will reach their ears not only through the earth, but through a longer or shorter intervening range of air, and hence at very different times and with very different amounts of repercussion and reverberation, although originating in one sound only, as of a single rend, or grind, or explosion.

A remarkable use has been made, for the first time, of the differences in the character of the sounds heard nearly simultaneously, and at about equal distances all round the Seismic vertical, in the Report

addressed to the Royal Society of the examination made on the facts of the Neapolitan Earthquake of 1857, by employing them to determine approximately from their varying character the form of the focal surface or cavity, or of the subterranean locus of the centre of effort,—and the method will no doubt hereafter, when more largely and completely applied, yield very important results. Space forbids us, however, here to do more than mention it, and refer to the Report in question.

These, then, are the waves produced by a *single* impulse, and constituting an Earthquake whose *origin is inland*. But should the *origin* be *under the sea*, then at the point passed through by the Seismic vertical and around it, the sea-bottom is, as on land, suddenly upheaved, and again dropped down; or it may be, as by submarine volcano, actually broken up altogether, and steam, lava, and floods of lapilli, and so forth, may be then belched forth under water. In either case there is forced up a volume of water upon the sea's surface just above, or several of these in succession, and as each mass falls again it assumes the horizontal form of a circular liquid wave of translation—and these are propagated outwards over the surface of the sea, like the circles or ring-shaped waves on a pond, when a pebble is dropped into it. The altitude and breadth of these waves depend mainly upon the magnitude of the disturbance of the bottom, and on the depth of water above it; the rate of their propagation outwards has nothing to do directly with elasticity, it is dependent simply upon the square root of the depth of the water traversed by the wave on its surface. If the ocean continued everywhere of the same depth, and the original impulse came from a single point, or circular disc, then the horizontal plan of the crest of any one of these waves would always remain a circle; but the depth varies—and as that part of the expanded circle which is over a deeper part moves on much faster than portions moving over shallow water, or approaching shores—so the circles soon get distorted into various other closed curves, and the original radial direction of translation outwards gets changed to any extent—so that a wave might, without any reflection, even double back upon its original line of progress.

When the long flat swell of such waves, as they are originated on the deep sea, approaches the shores and reaches shoal water, their fronts become steeper and steeper, and they finally roll in upon the shore, as the *great sea waves* of South American and other Earthquakes, so much dreaded wherever they have been once experienced. They are often so large that they only topple over as *breakers* after they have rolled in unbroken masses far inland.

Such was the wave that swept, in one unexpected deluge, thousands of people off the Quay at Messina, and which in some South American Earthquakes have inundated devoted cities like Valparaiso and Callao, with a frowning crest 80 feet in height. Not that the wave while it was far out at sea possessed anything like this altitude,—but just as the Atlantic tide wave,—when constricted in the Bay of Fundy, or in our own Bristol Channel reaches 70 or 40 feet; so does the Earthquake sea-wave rise and get steep in the narrow and shallow waters.

Thus, we see that in an Earthquake whose origin is beneath the sea, there may be a series of waves, all arriving in the following order, differently, and at different times, to an observer standing on the land.

1st. The great Earthquake wave of shock.

2nd. The *forced* sea-wave (of which we have as yet not spoken); it is the roll of water forced up by, and carried along with, the earth-wave, which raises the sea-bottom, and with it the water upon its back as it were, and at its own rate of motion, after it has got into shallow water. This is but occasionally perceptible, and only in great Earthquakes.

3rd. The sound-wave *through the earth*, which may or may not be before.

4th. The sound-wave *through the sea*.

5th. The sound-wave *through the air*.

All these except the second are elastic waves.

6th, and lastly. *The great sea-wave*, or wave of translation, rolls in and completes the catastrophe, often hours after the shock has done its work of destruction; or portions of it may roll in upon shores that have felt no shock at all. Thus in the great Earthquake at Japan, which a few years ago wrecked a Russian frigate in one of the harbours there, the great sea-wave produced in the deep seas, near those great Islands, hours afterwards, reached the opposite shores of the Pacific, at St. Diego and Francisco, and gave the first intelligence at those places of the disaster that had occurred at the further side of that great ocean.

Space forbids us now to pursue the subject further. At some future opportunity we may be enabled to revert to it; and to develope the relations between the movements of the elastic-wave particle and the wave's transit to which we have in the preceding pages almost confined our remarks. It remains also to be shown by what methods the position and depth, and even the form and magnitude of the deep-seated focus of an Earthquake, may be ascertained by deciphering, with the help of science, the terrible handwriting left by the destroyer upon the country it has overthrown. To these should be added some description of the *secondary effects* of Earthquakes, in moulding anew the features of the lands they pass over, and how those affect and modify the shocks that reach them. Something, too, might be said as to the distribution of Earthquakes in time and in space upon our Earth's surface; what are the conditions originating within our planet; the impulses on which their existence depends; and, lastly, what is the *function* of Earthquakes, and what uses they fulfil as parts of the great cosmical machine.

LIGHTHOUSE ILLUMINATION BY MAGNETO-ELECTRICITY.

By J. H. Gladstone, Esq., Ph.D., F.R.S.

Anyone who, on a tolerably clear night, has crossed the channel between Folkestone and Boulogne, and remained on deck, must have noticed on the French coast what appeared a brilliant star, now waxing, now waning. It was the light of the far-famed Pharos, on Cape Grisnez. But if he has made the passage within the last eighteen months, his gaze will have been attracted by a still brighter star on the British coast, of a bluish tint, steady and brilliant. This is the Magneto-electric Light at Dungeness, the brightest spark in the world, and one which unites a rare scientific with a practical interest, and may prove only the first lighted of a multitude of similar beacons. I propose to say a few words on the history, production, and merits of this Light.

History.—If we ask the parentage of the Magneto-electric Light, Mr. Frederick Hales Holmes is certainly its father, but, like other beings, it has had two grandfathers—the philosopher who first showed the conducting power of charcoal, and the brilliancy of the light between charcoal terminals of an interrupted galvanic current; and Professor Faraday, who discovered that when a piece of soft iron, surrounded by a coil of metallic wire, was made to pass by the poles of a magnet, an electric current was produced in the wire, which revealed its existence by effecting chemical decompositions, or by giving a spark. This spark, it is true, was barely visible as at first obtained, but it has been exalted into the present Magneto-electric Light.

It appears that in 1853 some large Magneto-electric machines were erected in Paris for producing gas by the decomposition of water, the object of the proprietor being to use this gas for the purposes of combustion; but the scheme failed, the Company that was being formed came to nothing, and the machines were pronounced by leading scientific men to be only expensive toys. Mr. Holmes, however, who was one of the referees, proposed to turn them to account for electro-plating and gilding, and thought it possible that the Electric Light might be produced advantageously by their means. "My propositions," he says, in his evidence before the Royal Commission on Lights, Buoys, and Beacons, "were entirely ridiculed, and the consequence was, that instead of saying that I thought I could do it, I promised to do it by a certain day. On that day, with one of Duboscq's regulators or lamps, I produced the Magneto-electric Light for the first time, but as the machines were ill-constructed for the purpose, and as I had considerable difficulty to make even a temporary adjustment to produce a fitting current, the Light could only be exhibited for a few minutes at a time—say ten or twenty minutes—when the adjustments were entirely displaced by the friction; the rubbing surfaces were worn away. From this time I directed my attention more particularly to the reconstruc-

tion of the machines entirely, from the very frame-work upwards, so as to produce the current that I saw necessary for the Electric Light." During this time, it appears that Mr. Holmes, not liking the treatment he received from the French Company, left Paris, and left his imperfect machine there, and it was this very machine which was subsequently used by the French Government in their experiments, and these experiments were carried on by a man who had worked under Mr. Holmes. The inventor next appears in Belgium, continuing his improvements with a new machine, and visited by Admiral (then Captain) Fitzroy, who was commissioned by the Admiralty to go to Brussels, see the Light, and report on it. In February, 1857, Professor Holmes applied to the Trinity Board, and in the following month the Electric Light was exhibited, for several nights, at the experimental lantern* at Blackwall, before the Light Committee and Professor Faraday. In May, an agreement was made for a trial at the South Foreland; but it was not till the 8th December that this experiment at an actual lighthouse was commenced. The Elder Brethren made arrangements for getting observations by the crews of pilot-cutters, masters of light-vessels, and the keepers of neighbouring lighthouses, both on the British and French coasts. Some unforeseen difficulties seem to have arisen, due partly, no doubt, to the novelty of the whole arrangement, but partly also to the complicated optical apparatus in the Lighthouse being suited to a large flame instead of a brilliant point of light, and being ill-adjusted to throw that light to the horizon. All this caused some interruptions in the experiment. M. Reynaud, the Director-General of the French Lighthouses, inspected the Light on April 26, 1859; it was visited by most of the Members of the Royal Commission of Lights, Buoys, and Beacons, including myself, three days afterwards, and on the same day Professor Faraday wrote a Report to the Trinity House. The opinions expressed were so far favourable, that the Elder Brethren desired a further trial of six months, during which time the Light was to be entirely under their own control, Mr. Holmes not being allowed to interfere in any way. The Light was again kindled on August 22, and the experiment happened soon to be exposed to a severe test, as one of the Light-keepers, who had been accustomed to the arrangement of the lamps in the lantern, was suddenly removed, and another took his place without any previous instruction. This man thought the light quite strong enough if he allowed the carbon points to touch, as the lamp then required no attendance whatever, and he could leave it in that way for hours together. On being remonstrated with, he said, "It is quite good enough." Notwithstanding such difficulties as these, the experiment was considered satisfactory, but it was discontinued at the South Foreland, for the cliffs there are marked by a double light, and the electric spark was so much brighter than the oil flames in the other house, that there was no small danger of its being seen alone in thick weather, and thus fatally misleading some unfortunate vessel.

Then occurred a period of two years, consumed partly in coming

* The room with glass sides, from which the light is exhibited at the top of a lighthouse, is called a "lantern."

to the decision that the Magno-electric Light was to be exhibited at Dungeness, and partly in fitting up the lighthouse there (which by the way had been cracked by lightning) for the reception of its new occupant.

It was not deemed desirable to trust the illumination of that headland entirely to the Electric Light, hence the old apparatus was retained, and the oil-lamp has always been kept ready for use in case of necessity. A supplementary lantern was therefore constructed on the top of the ordinary one, and in this the electric lamp was fixed, and surrounded by a small combination of lenses and prisms made expressly for it by Messrs. Chance, of Birmingham. In the meantime Mr. Holmes had considerably improved his lamp by borrowing an idea from an arrangement devised by a M. Serrin. At length, in February, 1862, this lamp was lit at Dungeness, but it was extinguished on account of the necessity of instructing fresh lighthouse keepers, who had to take charge of the apparatus, and it was not till the 6th of June that the brilliant star shone permanently on our Southern coast.

In the meantime, the French have not been indifferent or idle. When the Royal Commission visited Paris, the Lighthouse authorities were found experimenting with a comparatively small machine, and had clearly not overcome the difficulty of maintaining the charcoal points at a proper distance. But they persevered, and last July there was published in the 'Moniteur Universel' a Report by M. Reynaud to the Minister of Commerce and Public Works, in which he expressed a most favourable opinion of the Electric Light, and the Minister gave an order for two Electro-magnetic machines to be placed in the double Lighthouse of the Cap de la Hève, near Havre. Thus France is following England in the adoption of this improvement in coast lights, just as, years ago, Great Britain followed France in the use of the Dioptric system of illumination.

It is possible that some other nations may not be behind the French. The Dutch Government contemplate placing an Electric Light at Scheveningen, and a second one at Texel. The Lighthouse system in the empire of Brazil is excellent, and they have long had an eye on the Electric Light. Sweden is on the alert; and inquiries also have been made respecting its management and cost by the Imperial Academy of Vienna.

Apparatus.—Many readers will be familiar with the apparatus both of Mr. Holmes and of M. Berlioz, from having examined them at the International Exhibition last year. It would be very difficult to describe them without drawings, but the following may give a sufficiently good general idea. In the apparatus at Dungeness, the power that produces the light is resident in 120 permanent magnets, of about 50lbs. each, ranged on the periphery of two large wheels. This power is called into action by a steam-engine, with Cornish boilers, of about three-horse power, which causes a series of 160 soft iron cores surrounded by coils of wire to rotate past the magnets. The small streams of Electricity thus generated are collected together

into one stream, and by a special piece of apparatus called a Commutator the alternate positive and negative currents are all brought into one direction. The whole power is then conveyed by a thick wire from the engine-house to the lighthouse tower, and up into the centre of the illuminating apparatus. There it passes between two charcoal points, producing thus a most brilliant and continuous spark. The "Lamp," or "Regulator," is so contrived that by means of a balance arrangement and a magnet, round which the wire coils, the charcoal points are kept always at a proper distance apart.

At sunset the machine is started, making about 100 revolutions per minute; and the attendant has only to draw two bolts in the lamp when the power thus spun in the engine-room bursts into light of full intensity. It now requires little or no thought for three hours and a half, when the charcoal points being consumed the lamp must be changed, and this is done without extinguishing the light, for it is the kindling of the second lamp that puts out the first. There are always several lamps ready at Dungeness in case of accident, and everything is kept in duplicate.

The French machine is composed of 56 magnets distributed in 7 vertical equidistant planes, upon the angles of an octagonal prism. The maximum of intensity is obtained when the machine turns 350 or 400 times per minute, and the direction of the current is then reversed nearly 6,000 times per minute. There is no Commutator employed, and the alternate currents are not brought into one.

MERITS AND DEMERITS.—In favour of the Electric Apparatus, it may be stated without any fear of contradiction that the light is vastly more intense than that produced from the most powerful oil-lamp, or any practicable number of argand burners. In truth that now shining at Dungeness is the most brilliant light in existence. The following statement will illustrate this. Professor Faraday says of it, when at the South Foreland, "During the daytime I compared the intensity of the light with that of the sun, that is, it was placed before and by the side of the sun, and both looked at through dark glasses; its light was as bright as that of the sun, but the sun was not at its brightest." No other light in existence would have stood that test. Again, he describes an experiment at Dungeness:—"Arrangements were made on shore, by which observations could be made at sea about five miles off on the relative light of the Electric lamp, and the metallic reflectors with their argand oil lamps—[the light formerly used]—for either could be shown alone, or both together. . . . . The combined effect was a glorious light up to the five miles; then, if the Electric light was extinguished, there was a great falling off in the effect; though, after a few moments' rest to the eye, it was seen that the oil-lamps and reflectors were in their good and proper state. On the other hand, when the Electric light was restored, the glory rose to its first high condition. Then, whilst both were in action, the reflectors were shaded, and the Electric light left alone; but the naked eye could see no sensible *diminution;* nor when the reflectors were returned into effectual use, could it see any sensible *addition* to the whole light

power, though the telescope showed that the alteration in the lantern had taken place at the right time." M. Reynaud estimates the usual intensity of the light at from 180 to 190 standard Carcel burners.

This superiority of brightness is of practical service only in thick weather, for if the air be clear an ordinary first-class light under the old system answers every purpose of the mariner, and in fog no light is of any avail; but it scarcely requires demonstration that in certain intermediate states of the atmosphere, the brighter light will penetrate the haze, rain, or snow to a distance at which the other is perfectly invisible. There is nothing in the nature of the rays emitted to prevent its doing so, for when submitted to spectral analysis, the Electric light is found to contain every ray that the oil-flame does, and others beside. The returns of neighbouring lighthouse keepers, and of the masters of two of the lightships at the Goodwin Sands, during the experiment at the South Foreland, show this to be actually the case, and similar testimony is borne by the masters of passing vessels, the commanders of the Channel Steam Packets, and the pilots who frequent the neighbouring seas.

The peculiar bluish colour of the light as seen from a distance is another advantage, by distinguishing it from ships' lights, or lamps on shore; and practically this is a great object. Of course, it may be made red or green, or any other tint, by coloured glasses. Indeed it is peculiarly adapted for such a purpose. As the light can be interrupted and immediately rekindled with full intensity at pleasure, this light offers facilities for signaling which no other does. Each lighthouse might be made to repeat its own number all night long, if that were thought desirable. Another advantage is well stated in the words of Professor Faraday:—"In cases where the light is from lamp flames fed by oil, no increase of light at or near the focus or foci of the apparatus is possible beyond a certain degree, because of the size of the flames; but in the Electric lamp, any amount of the light may be accumulated at the focus, and sent abroad at, of course, an increased expense. In consequence of the evolution of the light in so limited a focal space, it may be directed seaward, diverging either more or less, or in a vertical or horizontal direction at pleasure, with the utmost facility. The enormous shadow under the light, produced by the oil-flame burner, which absorbs and renders useless the descending rays to a very large extent, does not occur in the Magneto-electric lamp; all the light proceeding in that direction is turned to account. The optical part of the arrangement, whether dioptric or reflecting, might be very small in comparison with those in use:" and, indeed, it is so at Dungeness. As there is always an extra steam-engine and machinery on the premises, and ready for work, the power, and the consequent light between the charcoal points, might at any time be doubled, if the state of the atmosphere seemed to require it.

It has already been remarked that in fog no light, however powerful, is of much avail, and public attention is now being directed to the necessity of improving our fog signals. It has been well observed in M. Reynaud's Report, "During foggy weather the supplementary steam-

engine might be employed in playing sonorous instruments, which would carry sound to a much greater distance than the bells to which we have recourse at present."

Against the advantages attending the use of this Electric light must be set the greater complexity of the instrument, and the consequent greater chance of derangement, or rather the necessity of providing lighthouse keepers of a superior order, and an engineer to inspect the machinery and keep it in repair. This demand for superior workmen is a difficulty we generally have to encounter in perfecting our engines either of peace or war.

The relative expense of the Magneto-electric light and the Fresnel lamp is a consideration that must not be overlooked, though it should not be allowed too much weight when we are dealing with the safety of valuable cargoes and priceless human lives. The original outlay in machinery for the Electric light is very large, but there must be set against this a considerable diminution in the cost of the apparatus used for directing the rays where they are wanted. The working expense consists of the coals burnt, the charcoal points used up, and the wear of the machinery, all of which perhaps scarcely exceeds the cost of oil under the old system. The magnets are said rather to increase in strength than to diminish by use. The salary of an engineer is a more serious item, but the expense may be greatly reduced by appointing one engineer to several lighthouses, if the electric system become common. Mr. Holmes estimates the working expenses of the electric apparatus as compared with the oil lamp, at about 400 against 290. The French estimate is, "Abstracting the expenses of the first establishment, it will be found that while the expenses of the annual maintenance of a lighthouse of the first order fed with colza oil rise to 9,421 francs 75 centimes, those of the same lighthouse illuminated by electricity would be 12,240 francs." Again, "The annual expense will be increased 29 per cent. in lighthouses of the first order, but it will have the effect of rendering the luminous intensity at least fivefold greater."

It has been objected that the light is too bright, dazzling the mariner and misleading him as to its distance, but experience will soon remove this source of error, and it is hard to understand how the light can produce any dazzling effect, unless exhibited at the head of a pier close alongside of which the mariner must steer his way. But for harbour lights it is not required. Its proper place is on the prominent points of the coast which are used as landfalls by vessels, and unless objections present themselves in the future which are as yet unknown, we may confidently anticipate that each of these headlands will in time be marked by its brilliant Electric light.

ON THE APPLICATION OF THE PRINCIPLE OF "CONSERVATION OF FORCE" TO PHYSIOLOGY.*

PART I. *The Relations of Light and Heat to the Vital Forces of Plants.*

By WILLIAM B. CARPENTER, M.D., F.R.S., F.L.S., F.G.S.

IN every period of the history of Physiology, attempts have been made to identify all the forces acting in the Living body with those operating in the Inorganic universe. Because muscular force, when brought to bear on the bones, moves them according to the mechanical laws of lever-action, and because the propulsive power of the heart drives the blood through the vessels according to the rules of hydraulics, it has been imagined that the movements of living bodies may be explained on Physical principles;—the most important consideration of all, namely, the source of that contractile power which the living muscle possesses, but which the dead muscle (though having the same chemical composition) is utterly incapable of exerting, being altogether left out of view. So, again, because the digestive process, whereby food is reduced to a fit state for absorption, as well as the formation of various products of the decomposition that is continually taking place in the living body, may be imitated in the laboratory of the Chemist; it has been supposed that the appropriation of the nutriment to the production of the living organized tissues of which the several parts of the body are composed, is to be regarded as a chemical action,—as if any combination of albumen and gelatine, fat and starch, salt and bone-earth, could make a living Man without the constructive agency inherent in the germ from which his bodily fabric is evolved.

Another class of reasoners have cut the knot which they could not untie, by attributing all the actions of living bodies for which physics and chemistry cannot account, to a hypothetical "Vital Principle"; a shadowy agency that does everything in its own way, but refuses to be made the subject of scientific examination; like the "od-force" or the "spiritual power" to which the lovers of the marvellous are so fond of attributing the mysterious movements of turning and tilting tables.

A more scientific spirit, however, prevails among the best Physiologists of the present day; who, whilst fully recognizing the fact that many of the phenomena of living bodies can be accounted for by the agencies whose operation they trace in the world around, separate into a distinct category—that of *vital* actions—such as appear to differ altogether *in kind* from the phenomena of Physics and Chemistry; and seek to determine, from the study of the conditions under which these present themselves, the *laws* of their occurrence.

In the prosecution of this inquiry, the Physiologist will find it greatly to his advantage to adopt the method of philosophizing which distinguishes the Physical Science of the present from that of the past

* To be concluded in our next Number.

generation; that, namely, which, whilst fully accepting the logical definition of the *cause* of any phenomenon, as "the antecedent, or the concurrence of antecedents on which it is invariably and unconditionally consequent" (Mill), draws a distinction between the *dynamical* and the *material* conditions; the former supplying the *power* which does the work, whilst the latter affords the *instrumental means* through which that power operates. Thus, if we inspect a Cotton-factory in full action, we find it to contain a vast number of machines, many of them but repetitions of one another, but many, too, presenting the most marked diversities in construction, in operation, and in resultant products. We see, for example, that one is supplied with the raw material, which it cleans and dresses; that another receives the cotton thus prepared, and "cards" it so as to lay its fibres in such an arrangement as may admit of its being spun; that another series, taking up the product supplied by the carding machine, twists and draws it out into threads of various degrees of fineness; and that this thread, carried into a fourth set of machines, is woven into a fabric which may be either plain, or variously figured, according to the construction of the loom. In every one of these dissimilar operations, the *force* which is immediately concerned in bringing about the result, is one and the same; and the variety of its products is dependent solely on the diversity of the material instruments through which it operates. Yet these arrangements, however skilfully devised, are utterly valueless without the force which brings them into play.* All the elaborate mechanism, the triumph of human ingenuity in devising, and of skill in constructing, is as powerless as a corpse, without the *vis viva* which alone can animate it. The giant stroke of the steam-engine, or the majestic revolution of the water-wheel, gives the required impulse; and the vast apparatus which was the moment previously in a state of death-like inactivity, is aroused to all the energy of its wondrous life,—every part of its complex organization taking upon itself its peculiar mode of activity, and evolving its own special product, in virtue of the share it receives of the one general force distributed through the entire aggregate of machinery.

But if we carry back our investigation a stage further, and inquire into the origin of the force supplied by the steam-engine or the water-wheel, we soon meet with a new and most significant fact. At our first stage, it is true, we find only the same mechanical force acting through a different kind of instrumentality; the strokes of the piston of the steam-engine being dependent upon the elastic force of the vapour of water, whilst the revolution of the water-wheel is maintained by the downward impetus of water *en masse*. But to what antecedent dynamical agency can we trace *these* forces? That agency, in each case, is Heat; a force altogether dissimilar in its ordinary manifestations to the force which produces sensible motion, yet capable of being in turn converted into it and generated by it. For it is from the Heat applied beneath the boiler of the steam-engine, that the non-elastic liquid contained in it derives all that potency as elastic

* In going through a manufacturing town, I have often been struck with the announcements of "Power to Let."

vapour, which enables it to overcome the vast mechanical resistance that is set in opposition to it. And, in like manner, it is the heat of the solar rays which pumps up terrestrial waters in the shape of vapour, and thus supplies to Man a perennial source of new power in their descent by the force of gravity to the level from which they have been raised.*

The power of the steam-engine, indeed, is itself derived more remotely from those same rays; for the Heat applied to its boilers is but the expression of the chemical change involved in combustion; that combustion is sustained either by the wood which is the product of the vegetative activity of the present day, or by the coal which represents the vegetative life of a remote geological epoch; and that vegetative activity, whether present or past, represents an equivalent amount of Solar Light and Heat, used up in the decomposition of the carbonic acid of the atmosphere by the instrumentality of the growing plant.† Thus in either case we come, directly or indirectly, to Solar Radiation as the mainspring of our mechanical power; the *vis viva* of our whole microcosm. Modern physical inquiry ventures even one step further, and seeks the source of the Light and Heat of the Sun itself. Are these, as formerly supposed, the result of combustion; or are they, as surmised by Mayer and Thomson, the expression of the motive power continually generated in the fall of aërolites towards the Sun, and as continually annihilated by their impact on its surface? Leaving the discussion of this question to Physical Philosophers, I proceed now to my own proper subject.

It is now about twenty years since Dr. Mayer first broadly announced, in all its generality, the great principle now known as that of Conservation of Force; as a necessary deduction from two axioms or essential truths—*ex nihilo nil fit*, and *nil fit ad nihilum*—the validity of which no true philosopher would ever have theoretically questioned, but of which he was (in my judgment) the first to appreciate the full practical bearing. Thanks to the labours of Faraday, Grove, Joule, Thomson, and Tyndall, to say nothing of those of Helmholtz and other distinguished Continental savans, the great doctrine expressed by the term "Conservation of Force" is now amongst the best established generalizations of Physical Science; and every thoughtful Physiologist must desire to see the same course of inquiry thoroughly pursued in regard to the phenomena of living bodies. This ground was first broken by Dr. Mayer in his remarkable treatise, 'Die Organische Bewegung in ihrem Zusammenhange mit dem Stoffwechsel' ('On Organic Movement in its relation to Material Changes,' Heilbronn, 1845); in which he distinctly set forth the principle that the source of all changes in the living Organism, animal as well as vegetable, lies in the forces acting upon it *from without;* whilst the changes in its own composition brought about by

* See on this subject the recent admirable address of Sir William Armstrong, at the Meeting of the British Association at Newcastle.

† This was discerned by the genius of George Stephenson, before the general doctrine of the Correlation of Forces had been given to the world by Mayer or Grove.

these agencies he considers to be the immediate source of the forces which are generated by it. In treating of these forces, however, he dwells chiefly on the production of Motion, Heat, Light, and Electricity by living bodies; touching more slightly upon the phenomena of Growth and Development, which constitute, in the eye of the Physiologist, the distinct province of vitality. In a Memoir of my own "On the Mutual Relations of the Vital and Physical Forces," published in 'The Philosophical Transactions for 1850,'* I aimed to show that the general doctrine of the "Correlation of the Physical Forces," propounded by Mr. Grove, was equally applicable to those Vital forces, which must be assumed as the moving powers in the production of purely Physiological phenomena; these forces being generated in living bodies by the transformation of the Light, Heat, and Chemical Action supplied by the world around, and being given back to it again, either during their life or after its cessation, chiefly in Motion and Heat, but also to a less degree in Light and Electricity. This Memoir attracted but little attention at the time, being regarded, I believe, as too speculative; but I have since had abundant evidence that the minds of thoughtful Physiologists as well as Physicists are moving in the same direction; and as the progress of science since the publication of my former Memoir would lead me to present some parts of my scheme of doctrine in a different form,† I venture again to bring it before the public in the form of a *sketch* (I claim for it no other title) of the aspect in which the application of the principle of the "Conservation of Force" to Physiology now presents itself to my mind.

If, in the first place, we inquire what it is that essentially distinguishes Vital from every kind of Physical activity, we find this distinction most characteristically expressed in the fact that a germ endowed with Life developes itself into an Organism of a type resembling that of its parent; that this organism is the subject of incessant changes, which all tend in the first place to the evolution of its typical form, and subsequently to its maintenance in that form, notwithstanding the antagonism of Chemical and Physical agencies which are continually tending to produce its disintegration; but that as its term of existence is prolonged, its conservative power declines so as to become less and less able to resist these disintegrating forces, to which it finally succumbs, leaving the organism to be resolved by their agency into the components from which its materials were originally drawn. The history of a living organism, then, is one of *incessant change;* and the conditions of this change are to be found

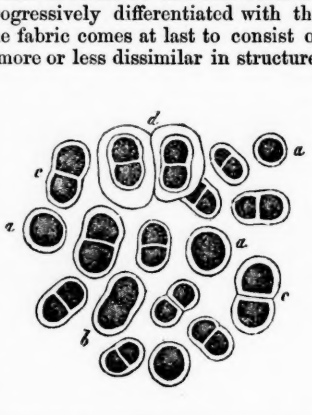
* At this date the labours of Dr. Mayer were not known either to myself or (so far as I am aware) to anyone else in this country, save the late Dr. Baly, who, a few months after the publication of my Memoir, placed in my hands the pamphlet 'Die Organische Bewegung;' to which I took the earliest opportunity in my power of drawing public attention in 'The British and Foreign Medico-Chirurgical Review' for July, 1851, p. 237.

† I have especially profited by a memoir on 'The Correlation of Physical, Chemical, and Vital Force, and the Conservation of Force in Vital Phenomena,' by Prof. Le Conte (of South Carolina College), in Silliman's 'American Journal' for Nov. 1859, reprinted in 'The Philosophical Magazine' for 1860.

partly in the organism itself, and partly in the external agencies to which it is subjected. That condition which is inherent in the organism, being derived hereditarily from its progenitors, may be conveniently termed its *germinal capacity:* its parallel in the Inorganic world being that fundamental difference in properties which constitutes the distinction between one substance, whether elementary or compound, and another; in virtue of which each "behaves" in its own characteristic manner when subjected to new conditions.

Thus, although there may be nothing in the aspect or sensible properties of the germ of a Polype to distinguish it from that of a Man, we find that each developes itself, if the requisite conditions be supplied, into its typical form, *and no other;* if the developmental conditions required by either be not supplied, we do not find a different type evolved, but no evolution at all takes place.*

Now the difference between a being of *high* and a being of *low* organization essentially consists in this;—that in the latter the constituent parts of the fabric evolved by the process of growth from the original germ are similar to each other in structure and endowments; whilst in the former they are progressively differentiated with the advance of development, so that the fabric comes at last to consist of a number of *organs* or instruments more or less dissimilar in structure, composition, and endowments. Thus in the lowest forms of Vegeable life, the primordial germ multiplies itself by duplicative subdivision (*a*, *b*, *c*, *d*) into an apparently unlimited number of cells, each of them similar to every other, and capable of maintaining its existence independently of them. And in that lowest Rhizopod type of Animal life, the knowledge of which is among the most remarkable fruits of modern biological research, "the Physiologist has a case in which those vital operations which he is elsewhere accustomed to see carried on by an elaborate apparatus, are performed without any special instruments whatever; a little particle of apparently homogeneous jelly changing itself into a greater variety of forms than the fabled Proteus, laying hold of its food with-



* It is quite true that among certain of the lower tribes both of Plants and Animals—especially the *Fungi* and *Entozoa*—similar germs may develope themselves into very dissimilar forms, according to the conditions under which they are evolved; but such diversities are only of the same kind as those which manifest themselves among *individuals* in the higher Plants and Animals, and only show that in the types in question there is a less close conformity to one pattern. Neither in these groups, nor in that group of *Foraminifera* in which I have been led to regard the range of variation as peculiarly great, does any tendency ever show itself to the assumption of the characters of any group fundamentally dissimilar.

out members, swallowing it without a mouth, digesting it without a stomach, appropriating its nutritious material without absorbent vessels or a circulating system, moving from place to place without muscles, feeling (if it has any power to do so) without nerves, propagating itself without genital apparatus, and not only this, but in many instances forming shelly coverings of a symmetry and complexity not surpassed by those of any testaceous animals,"* whilst the mere separation of a fragment of this jelly is sufficient to originate a new and independent organism, so that any number of these beings may be produced by the successive detachment of such particles from a single Rhizopod, each of them retaining (so far as we have at present the means of knowing) the characteristic endowments of the stock from which it was an offset.

When, on the other hand, we watch the evolution of any of the higher types of Organization, whether Vegetable or Animal, we observe that although in the first instance the primordial cell multiplies itself by duplicative subdivision into an aggregation of cells which are apparently but repetitions of itself and of each other, this homogeneous extension has in each case a definite limit, speedily giving place to a structural differentiation which becomes more and more decided with the progress of development; until, in that most heterogeneous of all types—the Human Organism—no two parts are precisely identical, except those which correspond to each other on the opposite sides of the body. With this structural differentiation is associated a corresponding differentiation of function; for whilst in the Life of the most highly developed and complex organism we witness no act which is not foreshadowed, however vaguely, in that of the lowest and simplest, yet we observe in it that same "division of labour" which constitutes the essential characteristic of the highest grade of Civilization. For in what may be termed the elementary form of Human Society, in which every individual relies upon himself alone for the supply of all his wants, no greater result can be obtained by the aggregate action of the entire community than its mere maintenance; but as each individual selects a special mode of activity for himself, and aims at improvement in that speciality, he finds himself attaining a higher and yet higher degree of aptitude for it; and this specialization tends to increase as opportunities arise for new modes of activity, until that complex fabric is evolved which constitutes the most developed form of the Social State, wherein every individual finds the work—mental or bodily—for which he is best fitted, and in which he may reach the highest attainable perfection; while the mutual dependence of the whole (which is the necessary result of this specialization of parts) is such that every individual works for the benefit of all his fellows, as well as for his own. As it is only in such a state of society that the greatest triumphs of human ability become possible, so it is only in the most differentiated types of Organization that Vital Activity can present its highest manifestations. In the one case as in the other does the result depend upon a process of gradual *development*, in which, under the

* See the Author's 'Introduction to the Study of the Foraminifera,' published by the Ray Society, 1862: Preface, p. vii.

influence of agencies whose nature constitutes a proper object of scientific inquiry, that *most general* form in which the fabric—whether Corporeal or Social—originates, evolves itself into that *most special* in which its development culminates.

But notwithstanding the wonderful diversity of structure and of endowments which we meet with in the study of any complex Organism, we encounter a harmonious unity or co-ordination in its entire aggregate of actions, which is yet more wonderful. It is this harmony or co-ordination, whose tendency is to the conservation of the organism, that the state of Health or Normal Life essentially consists. And the more profound our investigation of its conditions, the more definite becomes the conclusion to which we are led by the study of them,—that it is fundamentally based on the common origin of all these diversified parts in the same germ, the vital endowments of which, equally diffused throughout the whole fabric in those lowest forms of organization in which every part is but a repetition of every other, are differentiated in the highest amongst a variety of organs, acquiring in virtue of this differentiation a much greater intensity.

Thus, then, we may take that mode of Vital Activity which manifests itself in the evolution of the germ into the complete organism repeating the type of its parent, and the subsequent maintenance of that organism in its integrity,—in the one case, as in the other, at the expense of materials derived from external sources,—as the most universal and most fundamental characteristic of Life; and we have now to consider the nature and source of the *Force* or *Power* by which that evolution is brought about. The prevalent opinion has until lately been, that this power is inherent in the germ; which has been supposed to derive from its parent not merely its material substance, but a *nisus formativus*, *Bildungstrieb*, or *germ-force*, in virtue of which it builds itself up into the likeness of its parent, and maintains itself in that likeness until the force is exhausted, at the same time imparting a fraction of it to each of its progeny. In this mode of viewing the subject, all the organizing force required to build up an Oak or a Palm, an Elephant or a Whale, must be concentrated in a minute particle, only discernible by microscopic aid; and the aggregate of all the germ-forces appertaining to the descendants, however numerous, of a common parentage, must have existed in their original progenitors. Thus, in the case of the successive viviparous broods of *Aphides*, a germ-force capable of organizing a mass of living structure, which would amount (it has been calculated)* in the tenth brood to the bulk of 500 millions of stout men, must have been shut up in the single individual, weighing perhaps the 1-1000th of a grain, from which the first brood was evolved. And in like manner, the germ-force which has organized the bodies of all the individual men that have lived from Adam to the present day, must have been concentrated in the body of their common ancestor. A more complete *reductio ad absurdum* can scarcely be brought against any hypothesis; and we may consider it proved that, in some way or

* See Prof. Huxley on the "Agamic Reproduction of Aphis," in 'Linn. Trans.,' vol. xxii. p. 215.

other, fresh organizing force is constantly being supplied *from without* during the whole period of the exercise of its activity.

When we look carefully into the question, however, we find that what the *germ* really supplies is not the force, but the *directive agency;* thus rather resembling the control exercised by the superintendent builder who is charged with the working out the design of the architect, than the bodily force of the workmen who labour under his guidance in the construction of the fabric. The actual constructive force, as we learn from an extensive survey of the phenomena of life, is supplied by Heat; the influence of which upon the rate of growth and development, both animal and vegetable, is so marked as to have universally attracted the attention of Physiologists: who, however, have for the most part only recognized in it a *vital stimulus* that calls forth the latent power of the germ, instead of looking upon it as itself furnishing the power that does the work. It has been from the narrow limitation of the area over which physiological research has been commonly prosecuted, that the intimacy of this relationship between Heat and the Organizing force has not sooner become apparent. Whilst the vital phenomena of Warm-blooded Animals, which possess within themselves the means of maintaining a constant temperature, were made the sole, or at any rate the chief, objects of study, it was not likely that the inquirer would recognize the full influence of external heat in accelerating, or of cold in retarding, their functional activity. It is only when the survey is extended to Cold-blooded Animals, and to Plants, that the immediate and direct relation between Heat and Vital Activity, as manifested in the rate of growth and development, or of other changes peculiar to the living body, is unmistakably manifested. To some of those phenomena which afford the best illustrations of the mode in which Heat acts upon the living organism, attention will now be directed.

Commencing with the Vegetable kingdom, we find that the operation of Heat as the "motive power," or dynamical agency, to which the phenomena of growth and development are to be referred, is peculiarly well seen in the process of Germination. The seed consists of an embryo which has already advanced to a certain stage of development, and of a store of nutriment laid up as the material for its further evolution; and in the fact that this evolution is carried on at the expense of organic compounds already prepared by extrinsic agency, until (the store of these being exhausted) the young plant is sufficiently far advanced in its development to be able to elaborate them for itself, the condition of the germinating embryo resembles that of an Animal. Now the seed may remain (under favourable circumstances) in a state of absolute inaction during an unlimited period. If secluded from the free access of air and moisture, and kept at a low temperature, it is removed from all influences that would on the one hand occasion its disintegration, or on the other would call it into active life. But when again exposed to air and moisture, and subjected to a higher temperature, it either germinates or decays, according as the embryo it contains has or has not preserved its vital endowments—a question which only experiment can resolve. The

process of germination is by no means a simple one. The nutriment stored up in the seed is in great part in the condition of insoluble starch; and this must be brought into a soluble form before it can be appropriated by the embryo. The metamorphosis is effected by the agency of a ferment termed *diastase;* which is laid up in the immediate neighbourhood of the embryo, and which, when brought to act on starch, converts it in the first instance into soluble dextrine, and then (if its action be continued) into sugar. The dextrine and sugar, combined with the albuminous and oily compounds also stored up in the seed, form the "protoplasm" which is the substance immediately supplied to the young plant as the material of its tissues; and the conversion of this protoplasm into various forms of organized tissue, which become more and more differentiated as development advances, is obviously referable to the vital activity of the germ. Now it can be very easily shown experimentally that the *rate of growth* in the germinating embryo is so closely related (within certain limits) to the amount of Heat supplied, as to place its dependence on that agency beyond reasonable question; so that we seem fully entitled to say that Heat, acting through the germ, supplies the constructive force or power by which the Vegetable fabric is built up.* But there appears to be another source of that power in the seed itself. In the conversion of the insoluble starch of the seed into sugar, and probably also in a further metamorphosis of a part of that sugar, a large quantity of carbon is eliminated from the seed by combining with the oxygen of the air so as to form carbonic acid; this combination is necessarily attended with a disengagement of heat, which becomes very sensible when (as in malting) a large number of germinating seeds are aggregated together; and it cannot but be regarded as probable that the heat thus evolved within the seed concurs with that derived from without, in supplying to the germ the force that promotes its evolution.

The condition of the Plant which has attained a more advanced stage of its development differs from that of the germinating embryo essentially in this particular, that the organic compounds which it requires as the materials of the extension of the fabric are formed by itself, instead of being supplied to it from without. The tissues of the coloured surfaces of the leaves and stems, when acted on by light, have the peculiar power of generating—at the expense of carbonic acid, water, and ammonia—various ternary and quaternary organic compounds, such as chlorophyll, starch, oil, and albumen; and of the compounds thus generated, some are appropriated by the constructive force of the Plant (derived from the heat with which it is supplied) to the formation of new tissues; whilst others are stored up in the cavities of those tissues, where they ultimately serve either for the evolution

* The effect of Heat is doubtless manifested very differently by different seeds; such variations being partly *specific*, partly *individual*. But these are no greater than we see in the inorganic world; the increment of temperature and the augmentation of bulk exhibited by different substances when subjected to the same absolute measure of heat, being as diverse as the substances themselves. The whole process of "malting," it may be remarked, is based on the regularity with which the seeds of a particular species may be at any time forced to a definite rate of germination by a definite increment of temperature.

of parts subsequently developed, or for the nutrition of animals which employ them as food. Of the source of those peculiar affinities by which the components of the starch, albumen, &c., are brought together, we have no right to speak confidently; but looking to the fact that these compounds are not produced in any case by the direct union of their elements, and that a decomposition of binary compounds seems to be a necessary antecedent of their formation, it is scarcely improbable that, as suggested by Prof. Le Conte (*op. cit.*), that source is to be found in the chemical forces set free in the preliminary act of decomposition, in which the elements would be liberated in that "nascent condition" which is well known to be one of peculiar energy.

The influence of Light, then, upon the Vegetable organism appears to be essentially exerted in bringing about what may be considered a higher mode of chemical combination between oxygen, hydrogen, and carbon, with the addition of nitrogen in certain cases; and there is no evidence that it extends beyond this. That the appropriation of the materials thus prepared, and their conversion into organized tissue in the operations of growth and development, are dependent on the agency of Heat, is just as evident in the stage of maturity as in that of germination. And there is reason to believe, further, that an additional source of organizing force is to be found in the retrograde metamorphosis of organic compounds that goes on during the whole life of the plant; of which metamorphosis the expression is furnished by the production of carbonic acid. This is peculiarly remarkable in the case of the *Fungi*, which, being incapable of forming new compounds under the influence of light, are entirely supported by the organic matters they absorb, and which in this respect correspond on the one hand with the germinating embryo, and on the other with Animals. Such a decomposition of a portion of the absorbed material is the only conceivable source of the large quantity of carbonic acid they are constantly giving out; and it would not seem unlikely that the force supplied by this retrograde metamorphosis of the superfluous components of their food, which fall down (so to speak) from the elevated plane of "proximate principles" to the lower level of comparatively simple binary compounds, supplies a force which raises another portion to the rank of living tissue; thus accounting in some degree for the very rapid growth for which this tribe of Plants is so remarkable. This exhalation of carbonic acid, however, is not peculiar to Fungi and germinating embryos; for it takes place during the whole life of Flowering Plants, both by day and by night, in sunshine and in shade, and from their green as well as from their dark surfaces; and it is not improbable that, as in the case of the Fungi, its source lies partly in the organic matters absorbed; recent investigations* having rendered it probable that Plants really take up and assimilate soluble *humus*, which, being a more highly carbonized substance than starch, dextrine, or cellulose, can only be converted into compounds of the latter kind by parting with some of its carbon. But it may also take

* See the Memoir of M. Risler, "On the Absorption of Humus," in the 'Bibliothèque Universelle,' N. S. 1858, tom. i. p. 305.

place at the expense of compounds previously generated by the plant itself, and stored up in its tissues; of which we seem to have an example in the unusual production of carbonic acid which takes place at the period of flowering, especially in such plants as have a fleshy disk or receptacle containing a large quantity of starch; and thus, it may be surmised, an extra supply of force is provided for the maturation of those generative products, whose preparation seems to be the highest expression of the vital power of the Vegetable organism.

The entire aggregate of organic compounds contained in the vegetable tissues, then, may be considered as the expression not merely of a certain amount of the *material elements*, oxygen, hydrogen, carbon, and nitrogen derived (directly or indirectly) from the water, carbonic acid, and ammonia of the atmosphere, but also of a certain amount of *force* which has been exerted, in raising these from the lower plane of simple binary compounds to the higher level of complex "proximate principles;" whilst the portion of these actually converted into organized tissue may be considered as the expression of a further measure of force, which, acting under the directive agency of the germ, has served to build up the fabric in its characteristic type. This *constructive* action goes on during the whole Life of the Plant, which essentially manifests itself either in the extension of the original fabric (to which in many instances there seems no determinate limit), or in the production of the germs of new and independent organisms. —It is interesting to remark that the development of the more permanent parts involves the successional decay and renewal of parts whose existence is temporary. The "fall of the leaf" is the effect, not the cause, of the cessation of that peculiar functional activity of its tissues, which consists in the elaboration of the nutritive material required for the production of wood. And it would seem as if the duration of their existence stands in an inverse ratio to the energy of their action; the leaves of "evergreens," which are not cast off until the appearance of a new succession, effecting their functional changes at a much less rapid rate than do those of "deciduous" trees, whose term of life is far more brief.

Thus the final cause or purpose of the whole Vital Activity of the Plant, so far as the *individual* is concerned, is to produce an indefinite extension of the dense, woody, almost inert, but permanent portions of the fabric, by the successional development, decay, and renewal of the soft, active, and transitory cellular parenchyma; and, according to the principles already stated, the descent of a portion of the materials of the latter to the condition of binary compounds, which is manifested in the largely increased exhalation of carbonic acid that takes place from the leaves in the later part of the season, comes to the aid of external Heat in supplying the force by which another portion of those materials is raised to the condition of organized tissue. —The vital activity of the Plant, however, is further manifested in the provision made for the propagation of its race by the production of the germs of new individuals; and here, again, we observe that whilst a higher temperature is usually required for the development of the flower, and the maturation of the seed, than that which suffices to sus-

tain the ordinary processes of vegetation, a special provision appears to be made in some instances for the evolution of force in the sexual apparatus itself, by the retrograde metamorphosis of a portion of the organic compounds prepared by the previous nutritive operations. This seems the nearest approach presented in the Vegetable organism, to what we shall find to be an ordinary mode of activity in the Animal. That the performance of the generative act involves an extraordinary expenditure of vital force, appears from this remarkable fact, that blossoms which wither and die as soon as the ovules have been fertilized, may be kept fresh for a long period if fertilization be prevented.

The decay which is continually going on during the life of a Plant restores to the Inorganic world, in the form of carbonic acid, water, and ammonia, a part of the materials drawn from it in the act of vegetation; and a reservation being made of those Vegetable products which are consumed as food by Animals, or which are preserved (like timber, flax, cotton, &c.) in a state of permanence, the various forms of decomposition which take place after death complete that restoration. But in returning, however slowly, to the condition of water, carbonic acid, ammonia, &c., the constituents of Plants give forth an amount of Heat equivalent to that which they would generate by the process of ordinary combustion; and thus they restore to the inorganic world not only the *materials* but the *forces*, at the expense of which the Vegetable fabric was constructed. It is for the most part only in the humblest Plants, and in a particular phase of their lives, that such a restoration takes place in the form of *motion;* this motion being, like growth and development, an expression of the vital activity of the "zoospores" of Algæ, and being obviously intended for their dispersion.

Hence we seem justified in affirming that the Correlation between Heat and the Organizing force of Plants is not less intimate than that which exists between Heat and Motion. The special attribute of the Vegetable germ is its power of utilizing after its own particular fashion the Heat which it receives, and of applying it as a constructive power to the building-up of its fabric after its characteristic type.

THE REPUTED FOSSIL MAN OF THE NEANDERTHAL.

By Professor William King, Queen's University in Ireland, and Queen's College, Galway.

As it is my intention to confine myself to the consideration of the Neanderthal fossil with reference to its place in Nature, I must necessarily be brief in my remarks on the circumstances under which it occurred, and on its geological age.

The fossil was found in 1857, embedded in mud in a cave or fissure intersecting the southern rocky side of the ravine or deep narrow valley, called the Neanderthal, situated near Hochdal between Düsseldorf and Elberfeld. A small stream or rivulet, known as the Düssel, flows along a narrow channel about sixty feet below the lowest part of the fissure, and on one side of the valley.

It has long been known that human bones, belonging to an extinct race, and occurring in stalagmite along with the remains of the mammoth and other fossil animals, have been found in the limestone fissures or caverns of the lofty precipices which overhang the river Meuse, in Belgium, about seventy English miles south-west of the Neanderthal.

Lyell's late work, 'The Antiquity of Man,' contains a very lucid description of the Meuse caverns, and of the one under consideration. In both cases it is evident that we have examples of ancient swallow-holes, into which have been washed bones, mud, and gravel, when their openings existed in the bed of large and powerful rivers. It was doubtless by the incessant abrading action of such ancient streams, continued for countless ages, that the Neanderthal, and much of the broad valley of the Meuse, became scooped out.

Few Geologists will dispute that the Meuse caverns are of the same age as the flint-implement gravels of the Somme, and that both belong to the latest division of the glacial or (as I have lately termed it) Clydian period.* If we accept the physical conditions of the Meuse caverns as demonstrative of their having been filled up in that remote age, we cannot but recognize in the corresponding conditions of the Neanderthal fissure evidences which claim for it an equally high antiquity, notwithstanding certain differences seemingly supporting the opposite conclusion.

The want of stalagmite and the *doubtful* absence of remains of extinct animals in the Neanderthal fissure may be readily explained; and as to the physical differences, the Düssel is certainly not to be compared with the Meuse for size and abrading power, but it must be admitted that a mere rivulet may take quite as much time to scoop out a "ravine" as a river to excavate a considerable portion of a broad valley.

Having finished my preliminary remarks, I shall next proceed to notice the fossil itself.

According to Dr. Fuhlrott, of Elberfeld, the skeleton was found

* See 'Synoptical Table of the Aqueous Rock-Systems,' 5th edition.

by some workmen while quarrying the rock where the cave occurs; but, knowing nothing of the importance of the discovery, and being very careless about it, they secured chiefly only the larger bones. Fortunately these fell into the hands of Fuhlrott, and they were shortly afterwards described by Professor Schaaffhausen, of Bonn. The principal parts of the skeleton which have been preserved are the cranium; both thigh bones, perfect; a perfect right humerus; a perfect radius; the upper third of a right ulna corresponding to the humerus and radius; a left humerus, of which the upper third is wanting; a left ulna; a left ilium, almost perfect; a fragment of the right scapula; the anterior extremities of a rib of the right side; the same part of a rib of the left side; the hinder part of a rib of the right side; and two short hinder portions, and one middle portion of some other ribs.

The skeleton, or rather, as much as is preserved of it, is characterized by unusual thickness, and a great development of all the elevations and depressions for the attachment of the muscles. The ribs, which have a singularly rounded shape, and an abrupt curvature, more closely resemble the corresponding bones of a carnivorous animal, than those of man.*

Although a difficulty may be felt in resting a satisfactory argument upon merely the great size of its osseous framework, and the peculiar form of its ribs, it cannot but be admitted that these characters afforded some grounds for the belief, at first entertained, that the Neanderthal fossil had not belonged to a human being. Whether a more close examination of other parts of the fossil will confirm this hypothesis, it is the object of the present paper to determine.

The skull is deficient in its basal and facial portions, but retains all the parts lying above a line connecting the *glabella*—or space between the eye-brows—and the *centre* of the posterior part of the skull immediately above the hollow of the neck, to which the name occipital or posterior tubercle is given.† Fortunately the parts alluded to, which are of uncommon thickness, enable one to determine some highly important points in craniology.

The *frontal*—or bone of the forehead‡—possesses the upper border and roof-plate of the eye-sockets, the inter-orbital space, the orifices of the frontal sinuses, and both outer orbital processes: the upper part of the alisphenoid belonging to the right side appears also to be present. The *occipital*—or posterior bone—retains, in addition to the tubercle, the superior transverse ridges. The *parietals*—or upper side-bones—possess the impression of the temporal squamosal. The *temporals*—or lower side-bones—are broken off, though it would appear from Huxley's figure,§ that the mammillary portion of the left one is still preserved. The *lambdoidal suture*—or joining of the parietals

* See Busk's translation of Schaaffhausen's paper in the 'Natural History Review,' 1861, pp. 158–162.

† The line A A, in Fig. 1, Plate I., passes from the *glabella* to the occipital tubercle.

‡ The explanation of the individual parts of the skull is prefixed to Plates I. and II.

§ See 'Man's Place in Nature,' Fig. 23 A, facing page 138.

and the occipital—including the *additamentum*, is well marked; the *sagittal suture*—or joining of the parietals in the medio-longitudinal line of the skull—is obscure; while the *coronal suture*—or joining of the frontal and parietals in front of, and at right angles to the last-named *suture*—is but faintly marked at the crown and obliterated at the sides. The bounding line of the temporal muscles (situated on each side of the skull in front of, and above the ear) is tolerably well defined.

In general terms, the Neanderthal skull is of an elongated oval form, with a basal outline bearing much resemblance to that of the Negro cranium represented by Martin.* It is of large size, being about an inch longer than ordinary British skulls; in width, however, it does not much exceed them. The forehead, uncommonly low and retreating, terminates in front by enormously projecting brow or superciliary ridges, which, besides being very thick, slightly rounded on their anterior aspect, and rather strongly arched above the eye-sockets, extend uninterruptedly across from one side to the other. The outer orbital processes—or horns of the brow-ridges—are also unduly developed; being thick and projecting. On the whole, there is a remarkable absence of those contours and proportions which prevail in the forehead of our species; and few can refuse to admit that the deficiency more closely approximates the Neanderthal fossil to the anthropoid apes than to *Homo sapiens*.

The greatest width of the skull is towards its posterior part, and on a level not much higher than the mammillary region—a character which is essentially pithecoid or simial. In human skulls, the greatest width is considerably higher—usually on a line connecting the centres of ossification of the parietals:† on the contrary, the Neanderthal cranium, like that of the Chimpanzee, is without any particular prominency where those centres may be assumed to be situated.

In addition to possessing a low retreating forehead, the fossil skull is remarkably flattened at the vertex, which, according to Huxley, rises about 3·4 inches only above what is called the glabello-occipital plane:‡ in Man, the corresponding part is generally about an inch higher. From the vertex there is a slightly curving fall both towards the front and the back, ending in the former direction at the origin of the brow-ridges, and in the latter, at the occipital tubercle. The curving is more rounded and regular on the anterior half—particularly at the upper portion of the brow, which, in consequence, is somewhat prominent—than on the posterior half: on the latter, there is a slight depression just above the apex of the lambdoidal suture. The posterior fall of the Neanderthal skull, as a peculiarity, was first pointed out by Huxley, who remarks that "the occipital region slopes obliquely upward and forward, so that the lambdoidal suture is situated well upon the upper surface of the cranium:" in other words, when the glabello-occipital plane is made horizontal, the apex of the lambdoidal suture is decidedly in front of the posterior tubercle. In ordinary

* 'Natural History of Man and Monkeys,' Fig. 182, p. 120.
† Plate II. Fig. 5, *b*.
‡ See Plate I. Fig. 1, A A.

skulls, it is well known, the backward slope terminates near the apex of the lambdoidal suture, below which the occipital bone stands more or less vertical to the glabello-occipital plane. The Neanderthal cranium, in its posterior features, is approached by some savage races; also occasionally by a few inhabitants of the British Isles. Moreover, judging from the few data at our command, the approximation apparently characterized the ancient "Borreby people," and the extinct race of the Meuse, supposing the latter to be represented by a nearly perfect skull which Schmerling obtained from the Engis cave near Liège;* but in no human tribe extinct, or existing, do we find both the vertex and the occiput so depressed and ape-like. Well might Huxley have felt a "difficulty in believing that a human brain could have its posterior lobes so flattened and diminished as must have been the case in the Neanderthal man."

Much of the hinder half of the skull partakes of the slight roundness just noticed; but anterior to its greatest width, in the areas which were embraced by the temporal muscles, the sides are perpendicular, and their "fore and aft" outline is straight and remarkably long.

In these general characters, the Neanderthal skull is at once observed to be singularly different from all others which admittedly belong to the human species; and they undoubtedly invest it with a close resemblance to that of the young Chimpanzee, represented by Busk in his translation of Shaaffhausen's memoir.†

Another differential feature characterizes the fossil in question. In human skulls, even those belonging to the most degraded races, if the forehead be intersected at right angles to the glabello-occipital plane, on a line connecting the two outer orbital processes at their infero-anterior point, the intersection will cut off the frontal bone in its entire width, and to a considerable extent rising towards the coronal suture;‡ whereas in the Neanderthal skull, the same intersection will cut off only the inferior and little more than the median portion of the frontal.§ This is quite a simial characteristic, and rarely, if ever, occurs in man.‖

* This is the only speciality in which the Engis and Neanderthal skulls agree.

† See 'Natural History Review,' 1861, Plate IV. Fig. 6.

‡ See Plate II. Fig. 5, B B. § See Plate I. Fig. 1, B B.

‖ I have examined and made myself acquainted with skulls belonging to the principal races or varieties of man, in all of which the forward position of the forehead, relatively to the outer orbital processes, is the general rule. The Engis skull exhibits it, and the same appears to be the case with the Borreby one, judging from the figure in Lyell's 'Geological Antiquity of Man,' p. 86. It may be doubted that the Plymouth skull, represented by Busk ('Nat. Hist. Rev.' 1861, Pl. V. fig. 6), is an exception. I possess a very remarkable skull, probably about 500 years or more old, taken last summer out of the beautiful ruins of Corcomroo Abbey, situated among the Burren mountains, in county Clare, which offers a close approximation to the fossil in the depressed form of the forehead: indeed, although not altogether so abnormal in this respect as the Neanderthal skull, it has in appearance a better development, in consequence of the median part of its frontal being a little more rounded. There is no reason to believe that it belonged to an idiot, as it happens that most of the skulls lying about the ruins have a low frontal region. It is singular that the inhabitants of Burren a few hundred years ago should have been characterized by a remarkably depressed forehead, while those now living have a well-developed cranial physiognomy.

The last peculiarity is concomitant with another equally striking. Viewing the Neanderthal forehead with reference to the situation of that portion of the brain which it enclosed, we may plainly perceive that the frontal lobes of the cerebrum have been situated *behind* the outer orbital processes. As far as I have ascertained, we cannot say this of man; for, apparently, in all existing races, whose skull has not been modified by artificial pressure, the corresponding parts of the brain actually extend in *front* of the orbital processes.*

Notwithstanding the strong simial tendencies displayed by its general features, most of the writers who have described this skull do not appear to think otherwise than that it belonged to an individual of our species. There seems to be no doubt, whatever, on the part of the Honorary Secretary of the Anthropological Society, Mr. Carter Blake, that the Neanderthal fossil is specifically *identical* with Man. He considers it to be the remains of some poor idiot or hermit, who died in the cave where the bones were found.† His reasons, however, are obviously unsatisfactory. "In reply to the suggestion," observes Huxley, "that the skull is that of an idiot, it may be urged that the *onus probandi* lies with those who adopt the hypothesis. Idiotcy is compatible with very various forms and capacities of the cranium, but I know of none which present the least resemblance to the Neanderthal skull."‡ Blake admits that its frontal peculiarities give the cranium an "apparent ape-like character;" but if such peculiarities be the result of mal-development producing idiotcy, one would be equally justified in believing that the form of the skull of the gorilla, or chimpanzee, is also produced by disease of the brain. Schaaffhausen, seemingly, would have no hesitation in repudiating the idea that the frontal specialities of the fossil are the result of individual pathological deformity.§

In case it should be suggested that this remarkable cranium has received its form from artificial pressure, I may observe that no one who has described it seems to entertain such an opinion; indeed its symmetry, also noticed by Schaaffhausen, is quite opposed to the supposition that the skull has undergone any process of artificial modification.

Huxley, while admitting that it is the most ape-like and most brutal of all human skulls yet discovered, states that it is "closely approached" by some Australian forms, and "even more closely affined to the skulls of certain ancient people, who inhabited Denmark during the Stone period."‖ I have no intention to deny that there are gene-

* The Corcomroo skull, noticed in the previous footnote, although closely approximated to the Neanderthal one in its low forehead, and *this alone*, is strictly human in the forward extension of the frontal lobes of the brain relatively to the outer orbital processes.

† See 'Geologist,' vol. V. p. 207.

‡ See Lyell's 'Geological Antiquity of Man,' p. 85.

§ The writer of an article on Lyell's 'Geological Antiquity of Man,' in the last number of the 'Quarterly Review,' summarily disposes of the Neanderthal skull with the gratuitous assertion, that it is quite removed from the pithecoid type, and possibly belonged to an idiot.

‖ 'Man's Place in Nature,' p. 157.

ral features of resemblance between the Australian, Neanderthal, and ancient Danish crania; but it appears to me, judging from the figures (31 and 32) in the deeply philosophical work, 'Man's Place in Nature,' that a closer resemblance is assumed than really exists. No one would have any hesitation in admitting that the Borreby skull, represented under one of the figures cited, is strictly human,—nay, from what I have seen myself, I have no hesitation in saying that precisely the same cranial conformation is often repeated in the present day; but it has yet to be shown that any skulls hitherto found are more than *approximately* similar to the one under consideration.

The proposition at present contended for is apparently invalidated by the fact that, among certain species of animals—notably those under domestication—skulls very dissimilar from each other may be found. It is, therefore, to be apprehended that, however clearly the Neanderthal fossil may be shown to be inadmissible into the human species, an attempt will be made to set aside the consequent conclusion by an appeal to the fact alluded to. But this I contend is not a case in point, as will be evident after a moment's reflection on the various breeds of the Dog —the best known of our domesticated species. These breeds, so remarkably differentiated by cranial peculiarities, are *artificial*, whereas the varieties of mankind are *natural*. The dissimilar skulls met with in the former are merely striking illustrations of organic or structural modifiability, produced by what Darwin calls Natural Selection, but nothing more.

Again, some weight seems to be due to the consideration that the human species (in which I include all the existing races of man) is characterized by a great variety of skulls. We have abundant examples affording characters which closely link together the most dissimilar forms, so that it is impossible to draw a line of demarcation between the extremes of dolichocephaly and brachycephaly,* or between the lofty forehead of Indo-Europeans and the depressed one of the Australian. Nay, the most degraded race we are acquainted with — the Mincopies of the Andaman Islands — may be strictly regarded as closely affined by cranial conformation to the highest intellectual races. It might, therefore, be urged that the Neanderthal skull is simply an aberrant form, but which is, nevertheless, inseparably linked on to the Indo-European type. If sufficient has not yet been adduced to dispel this idea, the following additional evidences, referring to the particular parts of the bones composing the fossil cranium, will, it is thought, be deemed fully adequate for the purpose.

Commencing with the *Frontal*.—Fuhlrott and Huxley have satisfactorily shown that this bone is furnished with large frontal sinuses; and apparently they regard these as the cause of the excessive prominency of the superciliary ridges. It may be reasonably doubted, however, that this is the case. Frontal sinuses, it is well known, do not always coexist with prominent brow-ridges, as, for example, in the Australian and the Chimpanzee: on the other hand, the former may exist without being associated with any more than an ordinary de-

* Professor Retzius distinguished *long* skulls, and *short* or round skulls, respectively by the names *dolichocephalic* and *brachycephalic*.

velopment of the latter. I have seen frontal sinuses extending to nearly the origin of the outer orbital processes, and almost large enough, even at their termination, to admit the small finger to be inserted into them, yet the brow-ridges were not particularly prominent. But whether the Neanderthal sinuses extend the whole length of the brow-ridges, or they are simply confined to the region of the *glabella*, their large size, in either case, is unusual in man, and they more strongly approach to, or resemble, as the case may be, those of the Gorilla.

As to the excessive prominency of the brow-ridges,—instead of regarding this feature as having been produced by the frontal sinuses,—there is more probability that, like the other extraordinary "elevations and depressions" of the skeleton, pointed out by Schaaffhausen, it is another speciality consequent on the greatly developed muscular system, which, from what has already been stated, evidently characterized the so-called Neanderthal man.

The orbital cavities appear to have had a circular rim, as in certain apes, there being no angle in that part joining the glabella. This is a feature unknown in any of the human races: in them the orbits are always subquadrate.*

The roof of the orbital cavities is altogether less concave, particularly on the outer side, than in Man; and, although the inner extremity of the plate forming the roof is broken off, sufficient remains to show that the cavities contracted sooner than usual. The cavities also *appear* to have been uncommonly divergent: if this were actually the case, its significance would point towards one of the specialities of the Gorilla.

Temporals.—As already stated, only the impression of the upper *squamosal* is seen on the parietals; but it suffices to show, as pointed out by Huxley, that this part had a comparatively low arcuation: the highest point of the arch reaches little more than half the height it attains in ordinary human skulls. Besides occurring among apes, an equally low arcuated squamosal distinguishes the human fœtus; and in some savage races—Australians and Africans—the same part is also depressed, but not so much as in the fossil. The Engis and Borreby skulls are strictly normal in this particular.†

* In some apes the rim of the orbits is of the human form.

† Under this head may be noticed a part which appears to have been overlooked in the fossil. On an excellent cast, supplied by Mr. Gregory, of Golden-square, London, there occurs on the right side and in front of the squamosal impression a raised flattened plate, which looks like the upper portion of the alisphenoid (see Plate I. Fig. 1, *b*): the forward situation of this plate prevents it being taken for the anterior part of the temporal; besides, its posterior side exhibits what appears to be the impression of the squamosal. The anterior margin of the supposed alisphenoid is about an inch behind the outer orbital process. Dr. Knox long ago pointed out in a Tasmanian skull a square-shaped bone, nearly an inch in extent, interposed between the alisphenoid and the parietal. I perceive that this abnormality in a Tasmanian skull is represented in Fig. 225 of the beautiful edition, just published by Renshaw, of Dr. Knox's translation of Milne-Edwards' 'Manuel de Zoologie.' I have also seen the same bone, but only on the left side, of an "Australian" skull belonging to the Dublin University Museum. Perhaps this interposed bone corresponds, in nature as well as situation, to the flattened plate observable in the Neanderthal fossil.

Occipital.—The upper portion of this bone is quite semicircular in outline, its sutural (lambdoidal) border running with an even crescentic curve from one transverse ridge to the other:* generally in human skulls, including the Engis one, the outline approaches more or less to an isosceles triangle.† The width of the occipital at the transverse ridges is much less than is common to Man; and the disparity is the more striking in consequence of the widest portion of the fossil occupying an unusually backward position.

Taking into consideration the forward and upward curving of the upper portion of the occipital bone as previously noticed, its semicircular outline, and smallness of width, we have in these characters, taken together, a totality as yet unobserved in any human skull belonging to either extinct, or existing races; while it exists as a conspicuous feature in the skull of the Chimpanzee.

Parietals.—In Man the upper border of these bones is longer than the inferior one; but it is quite the reverse in the Neanderthal skull. The difference, amounting to nearly an inch, will be readily seen by referring to Figures 1 and 2, in Plate II.; the former representing the right parietal of a British human skull, and the latter the corresponding bone of the fossil. These figures also show that the Neanderthal parietals are strongly distinguished by their shape, and the form of their margins: in shape they are five-sided, and not subquadrate, like those of the British skull;‡ while their anterior and posterior margins have each exactly the reverse of the form characteristic of Man.

The *additamentum*, which undoubtedly gives the parietals their five-sided shape, is on a level with the superior transverse ridge, and much longer than usual. This peculiarity is common to the human fœtus: I have, likewise, observed an approach to it in a "Caffre" skull belonging to the Dublin University Museum, in which, also, the upper and lower borders of the parietals are about equal in length. But still the abnormality of the latter case is not at all so extreme as the condition observed in the fossil. These particular features also are characteristically simial; for in extending our survey to the Chimpanzee, and some other so-called Quadrumanes, their parietals are seen to present a great similarity to those of the Neanderthal skull.§

I have now, as it appears to me, satisfactorily shown that not only in its general, but equally so in its particular characters, has the fossil

* Plate II. Fig. 4. † Plate II. Fig. 3.

‡ The outlines were taken by pressing a sheet of paper on the parietals; and, when in this position, marking their margins by following the bounding sutures; next, by cutting the paper according to the lines given by the sutures, and allowing it to retain its acquired convexity: the outlines were then marked off on another sheet of paper. Possibly the antero-inferior angle of the Neanderthal parietal, as given in the figure, is not strictly correct, owing to the coronal suture being obliterated in that part, but I venture to state that it is approximately true.

§ On the cast, an incised line runs from the lambdoidal suture (where the *additamentum* joins it) towards the posterior tubercle. Is this the suture which occurs near and parallel to the transverse ridges in fœtal skulls, and occasionally in that of adults? In the skull of the "Caffre," noticed in the text, this suture, which is only seen on the right side, is situated above the ridge; but in the fossil, it is below this part.

under consideration the closest affinity to the apes. Only a few points of proximate resemblance have been made out between it and the human skull; and these are strictly peculiar to the latter in the *fœtal state*. The cranium of the human fœtus, however, possesses the lofty dome, the forward position of the frontal respectively to the outer orbital processes, the greatest width at the parietal centres of ossification, and the vertical occipital, which are so conspicuous in the adult, but which are remarkably non-characteristic of the Neanderthal skull. Besides, so closely does the fossil cranium resemble that of the Chimpanzee, as to lead one to doubt the propriety of *generically* placing it with Man. To advocate this view, however, in the absence of the facial and basal bones, would be clearly overstepping the limits of inductive reasoning.

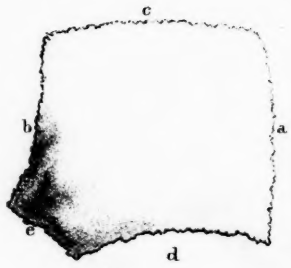
Moreover, there are considerations of another kind which powerfully tend to induce the belief that a wider gap than a mere generic one separates the human species from the Neanderthal fossil.

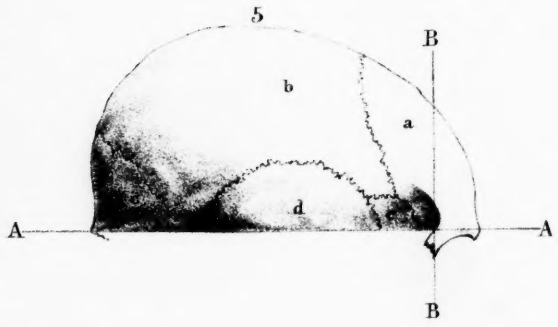
The distinctive faculties of Man are visibly expressed in his elevated cranial dome—a feature which, though much debased in certain savage races, essentially characterizes the human species. But, considering that the Neanderthal skull is eminently simial, both in its general and particular characters, I feel myself constrained to believe that the thoughts and desires which once dwelt within it never soared beyond those of the brute. The Andamaner, it is indisputable, possesses but the dimmest conceptions of the existence of the Creator of the Universe: his ideas on this subject, and on his own moral obligations, place him very little above animals of marked sagacity; * nevertheless, viewed in connection with the strictly human conformation of his cranium, they are such as to specifically identify him with *Homo sapiens*. Psychical endowments of a lower grade than those characterizing the Andamaner cannot be conceived to exist: they stand next to brute benightedness.

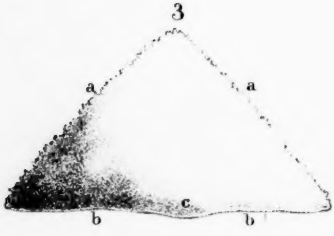
Applying the above argument to the Neanderthal skull, and considering that it presents only an approximate resemblance to the cranium of man, that it more closely conforms to the brain-case of the Chimpanzee, and, moreover, assuming, as we must, that the simial faculties are unimprovable—incapable of moral and theositic conceptions—there seems no reason to believe otherwise than that similar darkness characterized the being to which the fossil belonged.†

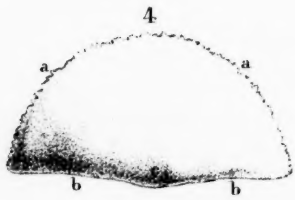
* It has often been stated that neither the Andamaners, nor the Australians, have any idea of the existence of God: there are circumstances, however, recorded of these races which prevent my accepting the statement as an absolute truth.

† A paper advocating the views contained in this article was read at the last meeting of the British Association, held in Newcastle-on-Tyne. In that paper I called the fossil by the name of *Homo Neanderthalensis;* but I now feel strongly inclined to believe that it is not only specifically but generically distinct from Man.









Allan A. King, Del. Banbury, Imp. Edwin M. Williams, Sc.

THE REPUTED FOSSIL MAN OF NEANDERTHAL (PLATE

Allen & King Del.

[illegible]

Edwin M. Williams Sc.

[illegible] FOSSIL MAN OF NEANDERTHAL [illegible]

EXPLANATION OF PLATE I.

FIG. 1.—*Right Side of Neanderthal Skull.*

A A. Glabello-occipital plane.
B B. Line intersecting the forehead at right angles to the last plane through both outer orbital processes.
(These lines are interrupted so as not to obscure any parts of the skull.)
a to a'. Border of squamosal impression.
(Letter 'a' is just below the widest part of the skull.)
b. ? Alisphenoid.
c. Portion of additamentum.

FIG. 2.—*Top of Neanderthal Skull.*

a, a. Outer orbital processes.
The transverse line on the middle of skull represents the coronal suture. (This and the corresponding line in Fig. 1 are copied from Busk's figures.)
The semicircular line at the posterior part of skull represents the lambdoidal suture.
The medio-longitudinal line represents the sagittal suture.

FIG. 3.—*Front of Neanderthal Skull.*

a, a. Outer orbital processes or horns of the brow-ridges.
b. Inter-orbital space.
c. Portion of roof-plate of right orbital cavity.
(Only the anterior half of the frontal bone is represented.)

*** The figures in this plate are taken from a plaster cast.

EXPLANATION OF PLATE II.

FIG. 1.—*Right Parietal of a Human (Irish) Skull.*

a. Coronal edge.
b. Lambdoidal edge.
c. Sagittal edge.
d. Squamosal edge.

FIG. 2.—*Right Parietal of Neanderthal Skull.*

a, b, c, d. Same as in last Figure.
e. Additamental edge.

FIG. 3.—*Occipital of a Human (Irish) Skull.*

a a. Lambdoidal edge.
b, b. Transverse ridges.
c. Occipital or posterior tubercle.

FIG. 4.—*Occipital of Neanderthal Skull.*

Letters same as in last Figure.

FIG. 5.—*Right Side-view of Dome of Human Skull*

A A. Glabello-occipital plane.
B B. Glabello-occipital intersecting plane.
a. Frontal.
b. Parietal. (The letter is on the centre of ossification and widest part of the skull.)
c. Occipital.
d. Temporal.
e. Alisphenoid.

CHRONICLES OF SCIENCE.

I. AGRICULTURE.

The movements in the Agricultural world during the past few months have related more to the business than to the Art of land cultivation. Agricultural Societies and Meetings have concerned themselves more with such questions as the relations of landlord and tenant, or of master and servant, than with details of the processes of the farm, or of the appliances by which they are carried out. And just in proportion as the motive—the efficient cause—is important in comparison with the mere machinery, so the nature of these business relations will, in any occupation or profession, always be the chief of all the influences affecting progress or success.

This is especially the case in Agriculture:—

When the landowner guarantees possession of a farm for a number of years, and does not restrict its cultivation to any precise routine of operations, he induces the tenant of that farm to apply all his mind and all his money to its management, for then there is given to him hope and opportunity of a reward for his outlay and his labour. The land is to a certain extent a machine, and its fertility depends on the use that it can make of the fertilizing influences of air and rain. Its powers as a machine in this respect can, in the case of wet and water-logged soils, be wonderfully increased; but the alterations needed for this purpose are very costly. Land-drainage, marling, liming, burning, are all expensive operations. A man may, in the case of wet clay soils, sometimes profitably spend nearly as much again in these improvements as the land is worth. It is folly to suppose that he will do this on the lands of another. They must be made his own on certain conditions and for sufficient time to enable him to reap the reward of that increased fertility which has been conferred. A lease is thus, for all purposes of considerable land improvement by the farmer, absolutely necessary.

Where, however, the improvements do not involve so large an expenditure, and where that expenditure can, under the several branches of it, be accurately recorded, it becomes possible so to keep an account between the landlord and tenant as to enable the former to repay the latter at any time, whatever may be due from the one to the other. And the system of tenancy at will, coupled with an agreement for the repayment of the balance of this account, does, in many parts of England, both maintain and promote a very high degree of cultivation. Nevertheless, this is but a makeshift arrangement, by which landowners hope to obtain the full advantage to all classes of a large expenditure of tenant's capital without in any degree abandoning those special privileges to themselves which the possession of landed property alone confers. And thus the Earl of Shrewsbury, at one of the recent discussions on the form of an agreement on this principle between landlord

and tenant, gave the fullest acquiescence to the principle of repaying the tenant for his outlay; but at the same time the completest refusal to the principle, far more influential for good, of granting leases to his tenants for terms of years. On the one hand, he said:—

"I should feel it to be dishonest if I allowed any tenant of mine to leave me in debt to him. If a man put on to a farm that which would improve it, I should feel bound not to let that man leave my estate without being remunerated for what is unexhausted."

On the other hand, he also said:—

"I adhere to what I have always said respecting leases, namely, that nothing will induce me to give a man a lease, because in the first place a lease is all on one side. The landlord remains, but the tenant, if he be inclined to be fraudulent, may go. I boldly and honestly state that I will never surrender my property to a tenant. I mean that no man who will allow his sons to poach and act disgracefully shall have control over my land for a number of years."

With whatever cordiality we may admire the evident honesty in every sense which these remarks display, it is also evident that they are dictated by an erroneous judgment, not only of the interest of landowners, but of the general character of tenantry.

The lease is not "all on one side." It not only confers advantages on the tenant, but it secures the annual payment of the sum at which those advantages have been valued by the landlord. The landlord does not "remain:" his successor may be either himself in a different mood of mind, or the inheritor of his estate; and in either case it is within his power to put an end to an unwritten bargain.

Again, a landlord does not "surrender his property to a tenant" under the lease, so much as the tenant is asked to surrender his property to the landlord under tenancy at will. Unlike the tenant's share in the improvements he confers upon the land he occupies, the land *remains*. Baron Liebig indeed speaks of the exhaustion of the land, but no such thing is known in practice. The "worn-out" farm of the practical man would be readily taken again by another tenant at the former rent, if only it were let to him for a year or two for nothing. Two years' rent, 3*l*. or 4*l*. per annum, are thus probably the utmost injury ordinary land receives by cross-cropping and hard usage. And if land be let on lease, you must suppose its tenant to be not only fraudulent but a fool, to do even this amount of injury to it. The fear which a landlord expresses lest his property should be injured by letting it out of his hands for so long a time is thus altogether visionary. The tenant's capital is to a great extent the cause of, and it is the security for, its fertility. That system which most encourages the outlay of this capital is best in the interest of the landlord as well as in that of the tenant and consumer.

And the fear of having an ill-conditioned set of neighbours permanently collected round you by granting leases, is equally visionary. It has been proved in other walks of life that the plan of universal restriction—of treating all men with suspicion—of making your general arrangements hinge on the possibility of every man being a rogue, is a blunder. It is an especial mistake in Agriculture. For

there is a certain class-colouring perceptible in farming, as in other professions, and tenant-farmers may be safely spoken of as a worthy and well-conditioned body of men. If, as is sometimes feared, a general prevalence of the lease should displace the homely and neighbourly class with whom in English country districts one has so long enjoyably associated, by a set of energetic, ruthless, restless, money-making "sharps," the change would be lamentable indeed; but the fear is ludicrous. However many new men may be entering Agriculture from other walks of life, it will always be that the bulk of farmers have been bred by farmers. And it is an easier and a better thing to engraft upon the characteristic good qualities of this class, or rather (for they already exist) to foster in them the intelligence and enterprise, and energy of commercial life, by adopting more generally a commercial view of the relations between landlord and tenant, than it will be to engraft a strict valuation and acknowledgment of tenant right upon the system of tenancy-at-will.

Although this Journal is devoted rather to the consideration of science than of business, yet the case of Agriculture, owing to the peculiarity of its raw material, land, is so exceptional, that these general remarks on what, more than anything else, determines its progress and improvement, may be permitted in a paper introductory to a quarterly series, descriptive of the progress and improvement which from time to time will have to be recorded.

And as a preliminary study of the subject which will thus at intervals engage us, we will now shortly enumerate the particulars in which this progress consists, or to which is owing increased produce of food from the land.

1. It is owing in the first place to better tillage. The object of tillage is the creation of an increased available surface within the soil, on which may be prepared and deposited food for plants, and over which the roots of plants may feed. The greater the quantity of this internal superficies to act as a laboratory, as a warehouse, as a pasturage, and the better stored it is, under a given extent of land, then so long as the fitness of the mechanical condition of the land with reference to particular plants is preserved, the more fertile is that land with reference to those plants.

In order to the creation of this inner surface a greater depth of soil is stirred, and clods are comminuted. In order to the increased accessibility of this inner surface land is drained. The air and rain water which then traverse soil and subsoil instead of merely lodging in them, introduce substances into this warehouse and activity into this laboratory.

The air which rain-water thus draws through the soil as it sinks downwards to the drains is as necessary to the fertility of the soil as it is to the heat of burning coals. The fire will merely smoulder until, by the erection of a chimney over it, a current upwards through the burning mass is impressed upon the air. And even then, in fires of caking coal, the heap may smoulder until, by the smashing of the fuel, that inner surface of the fire, where the action of the air takes place, throughout is multiplied, and the impervious ceiling—or floor, as we

might call it, to an upward current—which has hindered the passage of the air over that inner surface, is broken up.

Land drainage is the provision of a passage for the rain-water, along with which the fertilizing air has thus a downward current given it through the soil and subsoil. And tillage, especially tillage by steam-power, which does not cake a floor, as horse-power does, beneath the soil it stirs—has all that enlivening effect of the poker on a caked coal fire, which the parallel suggests. Extended drainage has a great deal to do with our increased produce. Mr. Bailey Denton estimates that nearly 2,000,000 acres have within the past fifteen years been under-drained, and the fertility of these acres has no doubt been largely increased.

Deeper and better tillage has contributed to the same result. The extension of autumnal tillage is an undoubted fact; the enormously increased use of implements of the grubber class is another; the general adoption of a better form of plough is a third; the more general adoption of the fertilizing practice of burning clay soils is a fourth. The success which has at length rewarded unconquerable perseverance in the attempt to use steam-power for tillage operations is a further great fact, which, if it cannot yet be quoted in explanation of agricultural progress, will unquestionably be looked back upon ten years hence as having contributed largely to the increased fertility which will then have to be recorded.

2. In the second place our agricultural progress has been owing to the greater richness of home-made manures, and to the greater use made of imported fertilizers. The imports of guano since 1840 have amounted to 3¼ millions of tons; the imports of cubic nitre, which averaged 10,000 to 14,000 tons per annum up to 1858, have since varied from 25,000 to 40,000 tons per annum. The imports of bones since 1848 have increased from 30,000 to 70,000 or 80,000 tons annually. All these are manuring substances. 75,000 to 80,000 tons of Suffolk and Cambridgeshire coprolites, and 15,000 to 20,000 tons of Sombrero phosphate, are also used in the superphosphate manufacture, which now probably exceeds in worth £1,000,000 per annum. To facts like this add the enormous extension in the use of oil cakes and richer foods in the meat manufacture, by which the richness of home-made manure is increased—the increased adoption of the practice of applying manure at once to the land, instead of rotting it in heaps, which is an economy, and so an addition to our resources worth naming—the increased practice of feeding and collecting manure under shelter, which is another great economy—and the increased care to properly pulverise and even dissolve manures, so as to distribute them thoroughly through the soil, which is another first-class example of a most important improvement in farm practice. On the other hand there is the increased value of the town sewage—due to the improved drainage of our towns—which is still suffered to go to waste. On the whole, however, there cannot be a doubt that the increased fertility of the soil is due not only to improved drainage and tillage, but to the direct application of fertilizing ingredients in a more liberal and economical manner.

3. Leaving now the soil, there is the way in which its increased

fertility is developed and expressed. It will on the whole be admitted that, at least on arable lands, there are fewer weeds; our fallow crops are cleaner, our tillage and manures are not so much wasted on plants we do not want to grow.

Another fact of importance is the prevalence of rotations of crops in which bare fallows are diminished, and in which there is a larger acreage of the more valuable crops. The prevalent rotation of the country is the four-field course, in which wheat, turnips, barley, and clover occupy one-fourth of the land apiece. But it is common on well-cultivated land—where the land is folded by cake-fed sheep, and where a top-dressing of guano is given to the corn, to take a crop of wheat between the turnips and the barley, so that three-fifths instead of two-quarters of the land are in grain crops. One-half of the clover land, too, is often sown instead with peas or beans, so that five-eighths instead of three-fifths are in grain. Again, over large districts, especially in Scotland, potato culture to a great extent displaces turnips or other fallow crops, and thus provides a great increase of food for man.

But besides the adoption of improved rotations, we have to report the improved cultivation of individual crops. We suppose that the gradually diminished quantity of seed used per acre in growing grain crops—as drill husbandry extends, and as an increased independence of mere custom becomes the rule, each man determining his practice for himself—will be admitted by most people as an example of this kind. Certainly every one will admit that the extension of drill husbandry in the cultivation of root crops, the extended use of the horse-hoe in the cultivation of grain crops—the extended use of so-called artificial manures as top-dressings and otherwise in the cultivation of all crops—all illustrate the improved cultivation of the plants by which the greater fertility of our soils is expressed and utilized.

Again, we owe our better crops to the selection and adoption of better sorts of the plants in cultivation. We do not suppose that individual sorts have improved upon our hands. Probably, as a general rule, they have deteriorated. But new sorts are being perpetually introduced; and of wheat, barley, and oats, mangold-wurzel, swedes, turnips and potatoes, cabbages and vetches, a man can grow sorts as good as any—we think probably better than any—that his predecessors have known.

4. We now come to the produce of meat, and the question of sort has a great deal to do with our improvement here. Our sheep are now ready for the butcher at 14 months old; our cattle at 24 and 30 months. Formerly it needed at least two years of feeding to make a smaller carcase of mutton, and at least three or four years' feeding to make a smaller carcase of beef. A thousand sheep upon a farm in March or April now mean something like 500 ewes in the lambing fold, and 500 sheep ready for the market. Formerly they meant not more than 300, and those a smaller lot ready for the butcher. And this great increase in the meat produce of a given head of stock is witnessed as much in pork and beef as it is in mutton.

All the important breeds of cattle, sheep, and pigs have improved

and increased in numbers during this period. Mr. Strafford receives entries for his herd book from fourfold the number of short-horn breeders; and the influence of this, the dominant breed of cattle, in crossing the general stock of the country, has wonderfully increased. Messrs. Duckham and Tanner Davy report no falling off in the number and quality of the more local breeds of Hereford and Devon. Both Down and long-woolled sheep, and especially the latter, have made great strides, both as to increase of numbers and general improvement; and much more general interest is taken in the improvement of the breeds of swine. The public attention has lately been drawn, or rather driven, to the fact that disease is rife among our stock, and it is said to be increasing. It is one great point in proof of great agricultural improvement that an evil of this kind, whether general or local, and wherever it exists, is not now left to fester, but is exposed and probed by an energetic public agitation, which will undoubtedly promote its cure.

The greater rapidity of growth, and the increased size of our improved stock, are owing partly to the better food we give our stock, as well as to their increased precocity, and the enormous extension of better bred stock. And thus, as part of this experience, we have a supply of more fertilizing manure and an increased growth of grain crops. It is, we believe, the fact that there are more acres of corn grown now than before has been ever known in England, and we look upon this as a proof of agricultural progress. And, so long as this is consistent with the maintenance of fertility, it is certainly for the interests of the consumer. It is said our climate is especially favourable for the growth of green crops. We believe there are more bushels of wheat per acre grown here than in any other country, whether we have so good a climate for it or not. And if the present extravagant cry for laying land down to grass which has hitherto grown grain and green crops in alternate husbandry shall to any extent prevail, we do not know who is to benefit by the change. Landlord, tenant, labourer, and consumer are alike interested in the larger produce and more energetic cultivation of arable land.

The progress which we have thus sketched has been achieved rather by the extension of good Agriculture than by the invention of any new process during the period of it; and yet there is enough of novelty and change apparent, too, on comparing the present farmer with his predecessor. Bones and rape-cake, soot and salt and gypsum, lime and marl, and composts used to be the principal methods of adding directly to fertility; and indirectly the same end was attained by the cultivation of successive green crops, feeding rye and rape, vetches and turnips, and cabbages off successively upon the same field. This "double" culture was advocated confidently as the perfection of arable cultivation twenty-eight or thirty years ago. Hear Mr. Middleton, who edited the 20th edition of Arthur Young's 'Farmer's Calendar,' writing on this very practice. "That very numerous class of supine persons," he says, "whose minds are so weak as not to adopt this practice, which is the most improved that is known, will certainly continue to complain of hard landlords and bad times. Such characters

do not succeed in any profession; neither can they in Agriculture. I had nearly said they deserve to be poor, but, whether they deserve it or not, their destiny is to be so."

Notwithstanding, however, Mr. Middleton's vigorous assertion of this practice, it is not thus that the farmer now in general seeks the increased fertility of his lands. He has guano, superphosphate, and other fertilizers at his command. He has machinery, not only for the increased efficiency, but for the cheapening of all agricultural processes. Steam-power both tills the soil and threshes out its produce. The mowing machine, hay-tedder, and reaper—the chaffcutter, pulper, and steamer—cheapen the labour of securing his crops, and economize the after-use of them. Better plants are grown, and better animals are fed, and the fertility which formerly came with profit under the best management in two or three years, is now achieved, with at least an equal profit, almost at once.

It will thus be seen that there is a large field over which the reader of the agricultural section of this Journal may expatiate. And in the improvements of machinery and soil, of manures, and plants and animals, there is scope enough both for the ingenuity and energy of the practical and scientific man, and in the present activity of both in the agricultural world, for the industry of the recording Journalist.

II. ASTRONOMY.

Germany, ever foremost in practical astronomy has, within the last few months, seen the inauguration of a movement likely, if well carried on, to render valuable services to the science. The celebrated band whose organization in the early years of the present century resulted in the discovery of the planetoids, Pallas, Juno, and Vesta, may be said to have paved the way for the new institution we have now to report upon, and there is no reason to doubt that the results in the present case will be equally, if not still more satisfactory. "The Astronomical Society of Germany," modelled in some respects on our own, is distinguished therefrom by including in its programme a scheme for united work which appears very promising. It is well known that there are certain classes of research demanding for their proper development more time and attention than a single observatory, much less a single observer, can possibly be expected to afford—variable stars and comet sweeping are two noticeable examples. By a well-adjusted subdivision of labour amongst several persons, each undertaking a prescribed department or area of the heavens, as the case may be, it is obvious that results of extreme magnitude and importance may be arrived at. A copy of the prospectus has been forwarded to us from Germany: from it we learn that Leipzic will be the general head-quarters, and that German will be the official language for the transaction of business, though the Society will be open to all nationalities and all languages. Both the entrance fee and annual subscription are fixed at five thalers (15*s.*), a very moderate sum by the side of

the three guineas and two guineas which our own Society charges for very inadequate returns. Amongst the officers elected at the Heidelberg foundation meeting, are Zech of Tübingen (President), Argelander, O. Struve, Bruhns, Schönfeld, &c. The secretary is Förster, of the Royal Observatory, Berlin, well known as an expert calculator.

In reviewing the progress of Astronomy during the last six months, we shall scarcely do wrong in assigning a foremost place to some remarks on the belief which has recently taken hold upon the minds of leading men, that it is now necessary to adopt some revised estimate of the sun's distance from the earth. The precise amount of the reduction to be made in the hitherto-received value is open to future determination, but concerning the general fact that some correction is requisite there seems to be no difference of opinion. The first really public announcement at any considerable length is due to Mr. Hind, who contributed a very lucid memoir on the subject to 'The Times' in the month of September last. For our present purpose no more is requisite than to give a brief recapitulation of the matter in Mr. Hind's own words, followed by a few general remarks on two of his heads which appear to deserve comment. He thus sums up:—"A diminution in the measure of the sun's distance now adopted is implied by—1st, the theory of the moon as regards the parallactic equation, agreeably to the researches of Professor Hansen and the Astronomer Royal; 2nd, the lunar equation in the theory of the earth, newly investigated by M. Le Verrier; 3rd, the excess in the motion of the node of the orbit of Venus beyond what can be due to the received value of the planetary masses; 4th, the similar excess in the motion of the perihelion of Mars, also detected within the past few years by the same mathematician; 5th, the experiments of M. Foucault on the velocity of light; and 6th, the results of observations of Mars when near the earth about the opposition of 1862."

To Encke we owe the best discussion of the observations of the transit of Venus in 1769: he determined the value of the sun's parallax to be 8″·5776, from which we infer the earth's mean distance from the sun to be 95,283,115 miles. Now, the time occupied by a ray of light reaching the earth from the sun is known very exactly to be 8m. 18s., from which a velocity of about 192,000 miles per second is deducible. Foucault of Paris, however, by the optical contrivance of a "turning mirror," due to Professor Wheatstone, has concluded that this value is too great; that it is more precisely 185,170 (English) miles. Assuming that Foucault is right, and all his predecessors wrong, it follows that the solar parallax must be 8″·86. Two most singular coincidences must here be disposed of. (1) The *theoretical* value assigned by Le Verrier, irrespective of all instrumental measurements, and purely on physical grounds, is 8″·95; and (2) The discussion, by Stone of Greenwich, of the observations of Mars (adverted to above in Mr. Hind's 6th point), taken by Ellery at Williamstown, Victoria, N. S. W., give a value of 8″·93, with a probable error of only 0″·03. Combining the foregoing, we find that three different observers, working in three most diverse ways, have all arrived at the same general result, and more than

this, at actual evaluations, the extremes of which differ only by the minute amount of 0″·09. Is it possible for us to withstand the conclusion that our estimations so long adhered to must sooner or later be materially "reconstructed," and as a consequence, that those portions of our treatises involving this distance must be unceremoniously pulled to pieces and built up again. An original calculation of the mean distance of the earth from the sun, amended according to Stone and Ellery's value of the parallax, makes it 91,512,649 miles.*

Chiefly in consequence of the larger major planets being, during the past autumn, unfavourably placed for observation, we have little to report in the department of planetary astronomy; the inferior conjunction of Venus on Sept. 28, is the only phenomenon of importance which has happened, and none of the observations which have as yet come under our notice contain any features calling for special remark.

The already very long list of minor planets has received one addition due to the labours of Mr. Watson, director, in succession to Brunnow, of the Observatory of Ann Arbor, Michigan, F.S.A. This planet, which takes the ordinal number of 79, was found on Sept. 14, shining as a star of the tenth magnitude. The following provisional elements have been determined by M. Allé, of Prague.†

Epoch 1863, Oct. 4·0, Berlin M. T.

Mean Longitude	=	23°	0′	54″·50	
Longitude of Perihelion . .	=	44	56	24·24	Mean Eq. 1863
Ascending Node	=	206	30	58·27	Mean Eq. 1863
Inclination of Orbit . . .	=	4	42	39·20	
φ	=	11	13	9·8	wherefore
		Eccentricity = 0·194563			
Log. Mean Distance . . .	=	0·3910464			
Mean Daily Motion . . .	=	919″·2568			

The new planet revolves round the sun in an orbit slightly larger than Parthenope's. It has not yet received a name.

On Nov. 13, M. Schmidt of Athens discovered another, the 80th, in the constellation Taurus. It shone then as a star of the tenth magnitude, but fell rapidly more than a whole magnitude in less than a week from that time.

On October 9 a watchmaker at Leipzic, surnamed Bäcker, had the good fortune to discover a small telescope comet, which Tempel of Marseilles found independently five days later.

The following elements are by M. Romberg:—

Perihelion Passage . . . . = 1863, Dec. 27·70863 G. M. T.

Longitude of Perihelion . .	=	180°	17′	53″·4	Apparent Eq.
Longitude of Ascending Node.	=	104	51	28·8	Oct. 14·5
Inclination of Orbit . . .	=	82	16	29·4	
Perihelion Distance . . .	=	1·3550			
Heliocentric Motion . . .	=	Direct.			

* It should be remarked that parallactic observations of Mars are not generally regarded as susceptible of a high degree of accuracy, and that therefore we shall have to wait for the next transit of Venus (in 1874) to become *well acquainted* with the precise extent of the required diminution of distance.

† 'Astronomische Nachrichten,' November 13, 1863.

These elements bear considerable resemblance to those of Comet ii. 1818. Hereafter it will be reasonable to inquire whether the two bodies are identical, thus adding another 'periodic' comet to our stock of knowledge. It may be added that these elements are not wholly dissimilar to those of Comets i. of 1840 and iii. of 1860; neither should the singular fact be passed over that the three first elements differ but 11°, 12°, and 3° from the corresponding ones of the Comet i. of 1863.

M. Tempel was worthily rewarded, on Nov. 4, for the industry he so untiringly displays, by discovering another comet, one visible to the naked eye, and therefore more than usually interesting.

The following elements are also by M. Romberg:—

Perihelion Passage	=	1863, Nov. 9·49923		
		°	′	″
Longitude of Perihelion . .	=	94	46	10·6
Longitude of Ascending Node	=	97	31	15·2
Inclination of Orbit . . .	=	78	6	46·5
Perihelion Distance . . .	=	0·70656		
Heliocentric Motion . . .	=	Direct.		

At the time of its discovery this comet was as bright as a star of the 4th magnitude, and it had a short tail. As its perihelion passage preceded that of Bäcker's comet it becomes Comet iv. of 1863, the latter being Comet v., inverting the order of discovery. Both are still visible.

Sidereal astronomy is a branch of the science which, from its very nature, makes progress less rapidly than most others. Labourers are here fewer, because, in many important respects, instruments equal to the work are somewhat scarce. Mr. Lassell, who is diligently engaged in scrutinizing the heavens through the fine atmosphere of Malta, has communicated to the Royal Society an interesting note on the well-known planetary nebula in Aquarius (1 ♅ IV. R. A. 20h. 56m.; δ 11° 56′ S.), in which the following passages occur:—"With comparatively low powers it appears at first sight as a vividly light-blue elliptic nebula, with a slight prolongation of the nebula, or a very faint star at or near the ends of the transverse axis." Under high powers and the most favourable circumstances, "I have discerned within the nebula a brilliant elliptic ring extremely well defined, and apparently having no connection with the surrounding nebula, which indeed has the appearance of a gaseous or gauze-like envelope, scarcely interfering with the sharpness of the ring, and only diminishing somewhat its brightness."

To the same Society, on Nov. 19, Sir John Herschel presented a work, which will, we think, equal any of his former efforts. We allude to a gigantic catalogue of all the known nebulæ, 5,063 in number, compiled from every available source. Sir John's own catalogue of 1833 furnishes 2,307 objects, his Cape observations 1,713 more, the residue being obtained from miscellaneous sources. The epoch chosen is 1860, and the information, arranged in twelve columns, furnishes, amongst other things, constants for reduction and copious synonyms. The catalogue is at present only in manuscript, but we trust that no more time than is absolutely necessary will elapse before this valuable

result of Sir John Herschel's indefatigable research is published to the world.

Stellar parallax, in the hands of M. Kruger of Bonn, has yielded results for the stars 21,258 of Lalande's Catalogue, and 17,415 of Oltzen's Zones. To the former he assigns a parallax of 0″·260, with a probable error of + 0″·02, and to the latter a parallax of 0″·247, with a probable error of 0″·021. From these determinations we must infer that these two stars, both telescopic, are nearer to us than either Capella, Polaris, Arcturus, or Sirius.

Of the various fields of active work open to amateur astronomers, none are so promising as observations on variable stars. The task is a hard one, and requires unquestionably great patience and perseverance, but to those endued with these gifts a fine future is open. The number of known variables is steadily increasing, and now exceeds one hundred, to which the indefatigable Pogson of Madras has added another member within the last few months. He designates it U. Scorpii, and its place for 1860 is R.A. 16h. 14m. 26·6s., δ 17° 33′ 36″ S. It is likely to prove an object of particular interest, having been found by the discoverer to pass through three entire magnitudes in little more than one month, a rapidity of change only known to be equalled by three other stars.

Astronomical photography, in the able hands of Mr. De La Rue and the Kew observers, is making steady progress, but nothing has occurred during the period over which our survey extends, calling for particular notice.

Solar photometry has recently received important development in America under the ingenious manipulation of Mr. Alvan Clarke, the well-known optician. A well of adequate depth not being at his disposal, he made use of a horizontal gallery 230 feet long, through which the sun's rays, on a very clear bright day, were made to pass by the agency of a prism and mirror to obtain the required reflection. He employed a lens $\frac{1}{34}$ of an inch focal length, and thus reduced the sun's diameter 93,840 times, when it presented a brilliancy "which was estimated at scarcely equal to α Lyræ." Mr. Clarke considers that ten per cent. loss will be a reasonable allowance for the reflections; and weighing some comparisons of α Lyræ without the lens, he gives it as the final result that the sun would have to be removed 103,224 times its present distance, for it to appear no brighter than the star referred to.

No review of this character can be complete without a chronicle of literary intelligence, and we shall therefore glance cursorily at the performances of 1863 and the promises of 1864, which can scarcely fail to be useful and interesting. An important reprint has been issued in France—a work by the celebrated astronomical king, Alphonso X. of Castile. It is divided into sixteen parts, commencing with a catalogue of the fixed stars. The royal author then treats of the apparatus and instruments necessary for observing the stars and *estrellas movediros*, or planets. Speaking of the constellations, he says of Ursa Major:—"Some astronomers have taken it for a wain with its pole, others say that it has the form of an animal which might as well be a lion, a

wolf, or a dog, as a male or female bear. Here then are heavenly animals inhabiting that part of the sky where this constellation is to be found, and recognized by ancient astronomers because they saw four stars in a square, and three occupying a right line. They must have been endued with a better eyesight than ours, and the sky must have been very clear. Since they say it is a she-bear, let it be one. They were very lucky in being able to distinguish it." King Alphonso was evidently much in advance of his age to speak thus slightingly of popular tradition; his work is a worthy monument of his energy and genius.

Mr. J. R. Hind has brought out a third edition of his 'Introduction to Astronomy,' which is decidedly the best arranged elementary manual in the English or any other language. A new catalogue of standard stars has been issued from the Harvard College Observatory, Cambridge, U.S.A. It is a compilation of right ascensions from the best catalogues, of 152 stars, with copious constants for reduction, creditably arranged by Mr. Truman Henry Safford. The year 1863 has, amongst other events, witnessed the successful starting of what is, as far as we have been able to ascertain, the first purely astronomical periodical ever issued in England. The 'Astronomical Register' occupies a field hitherto a wide waste, and deserves to find a place on every astronomer's table. The Rev. R. Main, Radcliffe observer at Oxford, has recently published a 'College Manual of Physical Astronomy,' designed for the use of students. After a long delay, rendered necessary by the discovery of certain collateral errors, the second portion of 'Bessel's Zones' has just been published in a handsome volume, at St. Petersburg. It will be recollected that Bessel observed a large number of stars lying between 15° S. and 45° N., down to the ninth magnitude inclusive; his observations having been left unreduced, the task was undertaken by the St. Petersburg Academy of Sciences, which entrusted the work to the hands of M. Weisse. The first portion, comprising 31,085 stars, lying within 15° on either side of the equator, was given to the world in 1846; but the second, containing 31,445 stars, lying in a zone extending 30° northwards of the parallel of 15°, for reasons above stated, did not appear till 1863.

At the head of literary announcements undoubtedly we must place a new edition of Admiral W. H. Smyth's world-renowned 'Cycle of Celestial Objects.' This book, long out of print, being constantly asked for, its venerable and gallant author decided some time since to reissue it with such alterations and additions as twenty years made requisite. The new edition is now in progress, the more laborious part of it having been undertaken by the Admiral's accomplished son-in-law, Mr. Isaac Flitcher, of Tarn Bank, Workington.

Though Mr. Carrington has abandoned the observatory for the brewery, his important Redhill results will nevertheless be made available,—so far at least as regards his solar-spot observations, which are now in a forward state for publication.

The Obituary of 1863 happily contains no more leading names than Edward Josiah Cooper of Markree, Esq., and ex-M.P. for the county of Sligo; Virgilio Trettenero of Padua; J. W. H. Lehman of Göttingen; and M. Weisse of Cracow.

III. BOTANY AND VEGETABLE PHYSIOLOGY.

The attention of the French government has been called to some experiments of M. Hooibrenk, a native of Holland, for obtaining, by artificial fecundation, a more abundant crop of cereals, vines, and fruit trees. These experiments have been carried on at Sillery, near Rheims, on the property of M. Jacquesson, the well-known wine-grower. They are simple and inexpensive: the apparatus employed in the case of cereals being a cord of from 25 to 30 yards long, upon which is fastened a stiff woollen fringe, about ten inches in length, the hanging threads of which touch one another, and have small shot attached at short distances. At the time of flowering, this apparatus is passed over the crop so as to brush it lightly, an operation which employs three persons, a man at either extremity, and a child to hold up the cord at the middle. The object of this operation, which has to be repeated three times at intervals of about two days, is to scatter the pollen, and bring a larger quantity of it into contact with the pistils, and thus to ensure fecundation on a larger scale than is done by the ordinary operations of nature. The whole apparatus costs only five or six francs, and the labour employed is also very cheap, while the results have shown a vast increase in proportion. A modification of the process, as applied to vines and fruit trees, has also been followed by marked improvement in the crops; and, as a consequence, two commissioners, named by the Minister of Agriculture, have visited the scene of the experiments during the past summer, and as they have been carried on simultaneously with the ordinary system of farming, a comparison of the results shows the advantages given by the "Méthode Hooibrenk" as follows:—

	Hooibrenk System.	*Old System.*
	Kilogrammes.	Kilogrammes.
Wheat	31	21
Rye	25·5	16
Barley	24	16
Oats	17	12

The Commissioners recommend a methodical examination into the subject, and the Emperor has decided that such an examination shall take place on the imperial farms of Fouilleuse and Fontainebleau.

Dr. F. Hildebrand, of Bonn, observing that in some tropical orchids, cultivated in the Botanic Garden, he found no ovules in the ovarium of the expanded flower, and that, nevertheless, he saw the enlargement of the ovarium after having applied the pollen to the stigma, has been led to make some interesting experiments upon this curious point, which has not escaped the notice of previous botanists. Observations on thirty different species of orchids proved that in the recently expanded flowers of orchids the ovules are never fully developed, while in some species, indeed, even the placentæ are not yet fully developed. After the application of pollen to the stigma, the enlargement of the ovarium begins, and before the pollen-tubes reach the placentæ or

ovules. The tubes of pollen, therefore, have no direct influence upon the original development of the ovules, but they act first on the enlargement of the ovarium, and by this enlargement indirectly on the ovules. Dr. Hildebrand deduces from all his experiments that in the formation of the fruit of orchids, the pollen acts in two different ways: on the one hand it effects the enlargement of the ovarium, and the development of the imperfect ovules without the pollen tubes directly touching the ovules; on the other hand it impregnates the ovules, directly touching the embryo-sac, and determining the development of one germinal corpuscle into an embryo. This independent action of the pollen upon the ovules is probably not peculiar to orchids, although it has thus been noticed in that family, but the remarkable facts lately pointed out by Darwin in his 'Fertilization of Orchids,' as well as those just referred to, bear singular testimony to the acumen of the late Robert Brown, who foresaw that a patient examination of the structure and action of the remarkable sexual organs of this family would be more likely than any other means to elucidate the difficult subject of generation in Phanerogamic plants.

A remarkable confirmation of Mr. Darwin's views of the fertilization of orchids by insects is afforded by a South African species (*Disa grandiflora*), described in the recently issued Linnæan Journal. None of these South African species have hitherto been examined in relation to their manner of fertilization. In *Disa* the labellum is greatly reduced in size, and the posterior sepal large, forming a spur containing nectar. The nectary thus stands behind the stigma and pollen masses, in a directly opposite position to that which it occupies in other orchids. Nevertheless, fertilization is effected by insects, by a very slight change in the form of the two upper petals, and in the position of the viscid discs of the pollen masses, which are widely removed from each other, and face outwards from the labellum towards the margin of the column. The upper sepal and two upper petals enclose the column, so that insects, to reach the nectar, are compelled to approach the flower in front; but as the column stands in the way of the nectary, insects must push their proboscis or head on either side of it, in order to reach the nectar. In Disa the caudicles of the pollinia do not undergo the movement of depression, as described by Mr. Darwin, in most British orchids, but the caudicles are naturally crooked. In this plant therefore, notwithstanding the remarkable difference in the position of the nectary, every part of the flower, by the aid of very slight modifications, has become so neatly co-ordinated to ensure fertilization through the agency of insects.*

In connection with the subject of fertilizing processes, a remarkable arrangement has been noticed, by F. Cohn of Breslau, in thistles. The five anthers cohere, forming a tube. At the time of flowering this tube is shut in at the top, enclosing the style. About this period

* It may be mentioned, in connection with the interest excited by orchidaceous plants of late, that M. F. G. Beer has lately published an elaborate work at Vienna, 'On the Morphology and Biology of the Orchidaceæ;' and some remarks by Prof. Asa Gray, on the Fertilization of some of the North American Orchids, will be found in 'Silliman's Journal' for September last.

the anther tube rises to about four millimetres above the extreme points of the corolla, and if the same be touched, pollen, in lumps, issues from the summit, the anther-tube at the same time undergoing a remarkable twisting. After a short interval this is repeated. The style gradually becomes elevated above the summits of the anther-tube, and by the time it projects about four or five millimetres beyond, the irritability has completely disappeared, having lasted at the most about twenty-four hours. When the styles are visible it is too late for instituting experiments. These phenomena are produced solely by the contraction of the filaments of the stamens, which on each touch instantly contract, and after a little, resume their former length. The expulsion of the pollen depends upon the anther-tube being drawn downwards upon the style by the contracting filaments, and then pushed up again.

The subject of the functions of vascular tissue causes some difference of opinion among botanists, some saying that although containing air at most seasons, they are filled with sap in spring, while others affirm that when once formed they contain only air. M. Gris has applied Fehling's solution, which deposits a red precipitate when boiled with a very small quantity of glucose, thus indicating the presence of an essential element of the sap. On plunging for a few moments into such a boiling solution, thick fragments of the wood of chestnut, beech, poplar, laburnum, &c., at the commencement of spring, and afterwards, cutting thin sections for the microscope, the precipitated oxide of copper is found clothing the inner face of the large vessels, and forming reddish threads visible to the naked eye. The precipitate is also abundant in the cells of the medullary rays, whence M. Gris concludes that the so-called lymphatic vessels (at all events in spring) contain a sap either identical with, or closely analagous to, that found in the cellular elements of these stems. The spiral fibres of the reticulated, annular and spiro-annular, and other similar vessels of herbaceous plants, also present, in their interior, the red precipitate when similarly treated.

With regard to one class of vessels concerning which very considerable modification of opinion has been necessary since their first discovery by Schultz, *viz.* the laticiferous tissue, M. Lestiboudois has instituted a systematic series of experiments, the results of which he communicates from time to time to the 'Comptes rendus.' He has established beyond doubt the existence, in certain plants, of vessels containing coloured liquids, and that these *vasa propria* are not mere excavations in the tissue, permeated by a thread of granuliferous tissue, but that, though probably at a late period, a delicate wall is developed, which constitutes it a distinct vascular system, though not in all points a counterpart of that of the blood-vessels of animals; nor do they fulfil precisely the same purpose. While not, however, regarding the contractility of these vessels as proved, he considers that he indisputably makes out a circulation of the liquid contents, not regularly from one point to another, but in such a manner that the granules are driven into all the ramifications of a more or less complicated network. In

addition to the true vessels which contain the proper juices of plants, and which may either be long rigid tubules without anastomoses, or thin flexuose, and branching, with frequent inosculations, there are certain reservoirs or utricles, and others in the form of intercellular passages (or meati), which present themselves in the form of slightly branching vessels, constituting now and then a sort of framework around cells—and some of which are simply irregular cavities produced by laceration. In another communication, M. Lestiboudois enlarges on the subject, and adds that this imperfect vascular system is not met with in the generality of plants, nor in all parts of the plant in which they occur—nor, therefore, is the laticiferous juice an essential element in the growth of plants. M. Lestiboudois refuses to recognize two categories of coloured juices, essentially differing from one another,—the one special, scented, and excrementitial, and the other vital and alimentary; and further, is of opinion that the terms *latex* and *laticiferous* vessels should be abolished, because they perpetuate an erroneous idea, by assigning to plants those centralized functions which they do not really possess, but which are peculiar to animals.

It is always an interesting matter to receive confirmation of the natural affinities of structure in groups which have already, from a general community of characters, been arranged by botanists in what are termed *natural orders*; and the researches of Mr. Gulliver among the minute crystals called *raphides* existing among the tissues of some plants tend to this result. Mr. Gulliver has distinguished the acicular crystals (or true raphides) from another class of crystals which occur among Phanerogamia, commonly in a more or less globular congeries, either naked or within a cell, and which he proposes to call *Sphæraphides*. The distribution of this latter class of crystals appears to be especially characteristic of the Caryophyllaceæ, Geraniaceæ, Paronychiaceæ, Lythraceæ, Saxifrageæ, and Urticaceæ, so that he has never failed to find them in a single species of these orders. But inasmuch as he further believes that few, if any, orders could be named in which Sphæraphides do not exist, it is questionable how far they might be available as botanical characters. With true raphidian tissue, however, the case is different; they occur so regularly and plentifully in some plants, and so sparingly or not at all in others, that they afford good characters by which certain orders may be readily distinguished from their allies of other orders. Thus if we confine the word *raphides* to the needlelike crystals commonly occurring in bundles, it may be the expression of a more universal diagnosis between such orders as the Onagraceæ and their next allies (and yet no less simple and sure), than any single character hitherto employed; and we could determine the affinities and contrasts of certain plants by a method at once easy and practical, and in the absence of those parts heretofore exclusively used for the descriptive distinctions. Mr. Gulliver speaks in a later communication thus strongly:—"No other single diagnosis for the orders in question is so simple, fundamental, and universal as this; and the orders to which

it applies should be designated *raphis bearing* or *raphidiferous.* Besides Onagraceæ, Dioscoraceæ, Araceæ, and Asparagaceæ are spoken of as truly raphidiferous orders.

M. B. Corenwinder has been making a series of observations upon the expiration of leaves by day and night. He finds that the amount of carbonic acid exhaled at night varies with the temperature and ceases at zero; nor is the property of absorbing carbonic acid and again decomposing it found in very young leaves and buds. Adult leaves, however, never exhale carbonic acid in the open air, and when they receive a full supply of light from all parts. The question whether leaves coloured red, brown, or purple, possess the same properties as green leaves, has also occupied his attention, and he asserts that they differ in nothing from green plants in regard to the property of absorbing carbonic acid under the influence of light, and exhaling it in darkness. It is therefore inexact to say, in an absolute manner, that it is by their *green* parts that leaves decompose carbonic acid under the influence of sunlight.

The abundance of minute organisms found at deep-sea bottoms in the Atlantic and elsewhere, and the remarkable facts disclosed by Dr. Wallich's deep-sea soundings in the expedition of Capt. M'Clintock, gave some colour to the idea that the vegetable Diatomaceæ exist in a living state at great depths, and Dr. Stimpson, an energetic young naturalist connected with the Smithsonian Institution at Washington, who examined the specimens taken at the depth of 2,700 fathoms, in latitude 46 N. and longitude 168 E., by Lieutenant Brooke, found some startling appearances. The armature consisted of three quills, each about three inches in length, fastened together, and placed in such a position that, when the lead struck the bottom, the quills would be forced perpendicularly into it, and thus become filled with mud from a stratum a few inches below the general surface of the sea-bottom. One of these quills, *cut in two in the middle*, contained Diatoms, apparently Coscinodisci, which appeared to Dr. Stimpson to be undoubtedly living, judging from their fresh appearance and the colours of their internal cell-contents. Dr. Wallich, however, argues that although the soft parts are retained in specimens obtained from extreme depths, they differ materially both in aspect and quality from those of Diatoms known to be living. Such Diatoms never present a trace of locomotion, which is so tenaciously retained by Diatoms under all other circumstances. Moreover, the Coscinodisci, which constitute the largest proportion of Diatoms found in deep-sea deposits, are essentially inhabitants of shoal water. They do not live imbedded in mud, but the upper waters teem with their frustules. Dr. Wallich therefore inclines to answer the question decidedly in the negative.

IV. CHEMISTRY.

In commencing the Chronicles of the progress of Science for the last few months, it becomes necessary to exercise considerable care in the choice of subjects to be mentioned, so as to avoid on the one hand the omission of anything likely to interest a large section of our readers, and on the other hand to keep our pages from being overburdened with a mass of facts, important, no doubt, to the student of one special science, but of no interest to those outside the circle. This precaution is especially necessary in a science like Chemistry, in which not only does every month bring forth new discoveries, but every week—nay, every day is marked by some valuable fact. Our readers must not therefore expect to find every fact, even those most important, recorded in these chapters, but it will at the same time be our endeavour so to select our topics as to constitute these pages a truthful mirror of the general progress of Science.

There have been few periods more fruitful in important chemical discoveries than that comprised within the last few months. Two new metals have been announced as belonging to the already numerous family of elementary bodies, one of which has been literally brought to light by spectrum analysis—that powerful analytical process which has already given us cæsium, rubidium, and thallium. The new arrival is due to the labours of two German chemists, F. Reich and T. W. Richter.* They were examining some impure chloride of zinc obtained from two Freyberg ores, in the expectation of finding thallium present. In the spectroscope no green line was seen, but the authors remarked an indigo blue line, which was till then unknown. Upon isolating the conjectural substance in the form of chloride, they found that it gave this blue line, so brilliantly sharp and persistent, that they at once came to the conclusion that it belonged to a hitherto unrecognized metal, to which they accordingly gave the name *indium*. In their memoir the authors give the characteristic properties of the new metal, which appears somewhat to resemble zinc, and describe several of its compounds. The discovery has been confirmed by other chemists of eminence, and there now appears to be no doubt whatever as to its accuracy. The same cannot be said respecting the new metal claimed by M. J. F. Bahr.† In the analysis of a highly complicated mineral, from the island of Röusholn, containing nearly all the metals of the aluminium group, the author obtained about 1 per cent. of what he supposed was a new addition to this numerous family. He proposes for it the name of *wasium*. The existence of wasium as a simple body has been since disputed by M. Nicklès, ‡ who asserts it to be a mixture of the known bodies yttrium, didymium, and terbium.

* 'Journal für praktische Chemie,' bd. lxxxix. p. 441.
† 'Annalen der Physik und Chemie,' vol. cxix. p. 572.
‡ 'Comptes Rendus,' Nov. 2.

The already known elementary bodies are being gradually brought within the domain of spectrum analysis. Phosphorus, which has been long known to communicate, under some circumstances, a green colour to flame, has been shown by MM. Christofle and Beilstein * to possess a very definite spectrum, consisting of three distinct green lines. This new test is likely to be of considerable use, as, by its means, this deleterious body has been shown to exist in many samples of good commercial iron, which were supposed to be free from this impurity.

Our knowledge of the recently discovered element, cæsium, has been greatly enlarged by its discoverer Bunsen.† For the original isolation of this interesting alkali, nearly 100,000 lbs. of the mineral water of Dürkheim were evaporated down, yielding, however, only 30 to 40 grains. He has since determined the atomic weight to the metal with great accuracy upon a somewhat larger quantity, and has obtained the same number as those given by Messrs. Johnson and Allen,‡ namely 133.

M. Rose has announced a no less important discovery than that of an entirely new series of metallic oxides.§ In his memoir he proposes a new nomenclature which, were it generally adopted, would be of great convenience to chemists. The new series, which he has discovered, consists of 1 of metal with ¼ of oxygen, and this he proposes to call *quadrantoxide;* the compound of 1 of metal with ½ of oxygen, variously named the suboxide or the protoxide, he proposes to call *semioxide;* the compound of equal atoms of metal and oxygen he calls *isoxide;* the compound of 1 of metal to 1½ of oxygen retains its name, *sesquioxide;* whilst the ordinary binoxide is called the *diploxide.* Only one quadrantoxide has as yet been formed and analysed, but reasons are given for supposing that the suboxide of silver is really the quadrantoxide, and it is very probable that quadrantichlorides of the alkali metals are also known. As might be expected from their composition, these new oxides are difficult to prepare, and are easily decomposed.

The mysterious body ozone, respecting which so much has been done but so little is known, is still occupying the attention of chemists. Schönbein has already shown that this body is formed when evaporation takes place, and M. Morin ‖ considers that the good effects observed when water is artificially evaporated during the ventilation of rooms, may be due to the formation of a certain quantity of ozonized oxygen. English writers on Ventilation always advocate the introduction of a certain amount of moisture into the air supplied to inhabited places, and this has been well carried out in the ventilation of the Houses of Parliament.

Few chemical manufactures have been developed so much of late years as that of the barium compounds, and its prospective applications are most numerous and important, although at the present day their

* 'Comptes Rendus.' † 'Phil. Mag.,' vol. xxvi. p. 241.
‡ 'Silliman's Journal,' vol. xxxv. p. 94. § 'Poggendorff's Annalen.'
‖ 'Comptes Rendus.'

use seems to be confined to the manufacture of green fire. M. Kuhlmann has lately entered very largely into the manufacture of different compounds of barium, with a view to their commercial introduction. The absorption of oxygen from the air by red-hot baryta, and its subsequent release at a higher temperature, in the form of pure gas, could be made of the greatest importance to metallurgical and furnace chemistry. A cheap method of making peroxide of barium would place us in possession of the valuable peroxide of hydrogen, which would be of incalculable use as a disinfectant, and also in many manufacturing processes. To the industrial chemist cheap caustic baryta would entirely revolutionize the alkali manufacture, whilst for many purposes it would supersede the ordinary alkalies. In the manufacture of crystal-glass, lead, the most costly ingredient, could be even now economically replaced by a barium compound, provided a few preliminary difficulties were overcome. Nitrate of baryta can also be economically employed in the preparation of blasting powder; the chromates of baryta can in many cases replace the more costly chromates of potash, and the same may be said of the ferrocyanides, all of which are largely used in dyeing. These are some of the more important applications of this earth, but an immense number of minor uses has also been proposed, and there is little doubt that it will shortly become as valuable in industrial as it already is in analytical chemistry.

The extraordinary prolificness of some organic chemists in the discovery of new bases, will cease to be surprising after the perusal of a paper by Mr. Broughton,* in which it is shown that the known general processes for their formation are competent to produce several sextillions of new ammonias. As most, if not all, of these compounds only require for their production certain known agents to be placed in contact, it is evident that chemists need not debar themselves from the title of original discoverers for lack of virgin soil on which to work.

The value of the element bromine in the arts and manufactures is daily increasing, and were its price reduced, its importance in many industrial operations can scarcely be over-estimated. Hitherto the only source has been sea-water, where it exists in the form of bromide of magnesium, one part of this salt being dissolved in 100,000 parts of water. Recent experiments, by M. Roux,† show that the water of the Dead Sea is more than 100 times richer in bromine than ordinary sea-water. Already we hear of proposals for the establishment of a factory near the Dead Sea, for the separation of this element. It is much to be desired that this inexhaustible store of so valuable an agent should be utilized.

Perhaps the most important point to determine in the analysis of a drinking water is the presence of nitric acid, as this body is so closely connected with putrescent organic matter. Hitherto, however, few chemists take note of it, owing, doubtless, to the difficulties which beset its detection when very dilute. Mr. R. Kestings‡ has now

* 'Chemical News,' vol. viii. p. 245.
† 'Comptes Rendus,' vol. lvii. No. 14.
‡ 'Annalen der Chem. und Pharm.'

shown that the alkaloid brucine is a most delicate test for nitric acid, being coloured rose-red by water, containing only the 100,000th part. It is to be hoped that more attention will in future be paid to the varying proportions of this acid in potable water, and that the warnings given by its presence will not be disregarded.

The subject of pure water for household purposes is so important that we again recur to it, to notice an invention of Dr. H. Schwartz, which appears to remedy perfectly the effects of the employment of lead pipes and cisterns. He converts the inner surface of the metal into an insoluble sulphide by boiling in it a solution of sulphur in soda. The result is that the water is perfectly kept from contact with the metal, and will be as free from contamination as if it had been passed through a glass pipe.

Some curious results of the inhalation of the vapour of glonoine (an oil obtained by the action of nitric acid on glycerine) have been given by Mr. Merrick.* It has long been known that this body produces violent headache, but these experiments show that it is a most powerful agent in its physiological action. In one case the fortieth part of a drop dissolved in spirit was swallowed on a piece of sugar. In two minutes the pulse had risen considerably, being accompanied with a violent headache. This continued for nearly half-an-hour, when the symptoms passed off. At another time, when a quantity of vapour was accidentally inhaled, the headache became almost intolerable, and was accompanied by a good deal of faintness and exhaustion, intolerance of light, and a feeling of great general distress and alarm. The violent toxical effects show that glonoine is a powerful poison, and, like most agents of this kind, will doubtless be employed in medicine.

The application of gun-cotton as a substitute for gunpowder in warfare has occupied the attention of a committee of scientific men for some time past. General Von Lenk, of the Imperial Austrian Artillery, has invented a system of preparation by which gun-cotton has been made practically available for warlike purposes. The committee have had the advantage of personal communication with the General, and in the report, which will shortly be issued, an abstract of which having been communicated to the British Association at Newcastle, we are promised a vast amount of information of the most important character. General Von Lenk has shown that perfect gun-cotton is a definite chemical compound; he has given accurate processes for its manufacture, and for the removal of all extraneous matter and traces of free acid. As thus prepared, it is no longer liable to spontaneous combustion, it can be stored for any length of time without deterioration, it is not impaired by damp, and may be immersed in water without injury, its original qualities returning unchanged when allowed to dry in the air. These are valuable properties, and when we add to them the absence of smoke, the entire freedom from fouling, the innocuous character of the products of combustion in com-

* 'Silliman's Journal,' vol. xxxvi. No. 107.

parison with those of gunpowder, and the far inferior heat imparted to the gun itself, it will be seen that the advantages attending the employment of gun-cotton, are so many and so important as to call imperatively for the fullest investigation.

From gun-cotton to armour-plated ships is a natural transition in these warlike days. Science seems to be at fault on the subject of the preservation of iron plates from oxidation and fouling. One of the best processes, that has yet come under our notice, is due to Messrs. Johnson and Calvert. They propose to coat the iron with a thin layer of metallic zinc, as in the ordinary process of galvanizing. Their results prove that the film of zinc exercises a great protective power against the corrosive action of sea-water; upwards of a year's exposure showing that four or five times as much corrosion took place in the case of uncoated as with galvanized iron plates. Whether galvanizing would prevent fouling, remains to be seen; we suspect it would rather aggravate this evil.

V. GEOLOGY AND PALÆONTOLOGY.

There is perhaps more difficulty in describing the periodical progress of Geology, than there is in recording that of any other science. The exactitude of the advance is less decided, the views set forth more speculative, and the facts given more open to objection or discussion, than is the case in any other department of intellectual investigation. In Chemistry, the discovery of an element or of some previously unknown compound, gives a fixed and tangible point from which to go onward to further knowledge. Every step is a permanent score in the continuous tally. So the discovery of a comet or a planet, or a nebula, or more exact measurements of angles, or of distances, or the detection of errors of observation, or calculations or the revelations of increased telescopic powers, all yield for Astronomy definite and incontrovertible results, and it is only in the special sphere of absolutely speculative Astronomy, that there is any uncertainty whatever. So, too, in Botany, a new flower, or a flora of some previously unnoticed region, is so much substantially added to the previous knowledge, so much gain which can be appreciated and recorded. But in Geology, we have to deal with the rags and shreds of former ages and former beings, nothing whole or entire,—every relic has to be dug out of the *débris* and ruins, which we have, as it were, first to clear away before we can get a glimpse of any treasures remaining beneath, and when we find these they are damaged and mostly broken fragments which we have to join and fit, and put together, to get, in the best way we can, some general notion of what they originally were. Thus it is a new geological idea gets started, and is discussed, opposed, supported, until finally substantiated or disproved; in short, it is only after a contest that, generally speaking, any progress in this science is admitted. In

a quarterly summary of the nature of the present article, there must necessarily therefore be, as a rule, less definiteness and more hesitation and uncertainty than one would wish, but notwithstanding this inherent difficulty in the task, it is perfectly possible to give a concise and clear account of what is new and what is changing; but it must be more or less the newness of theories as well as of facts, bearing always in mind that geological facts are first provisionally accepted on the reliability of the observer, and are often open not only to questioning but to reversal. Thus for many years the older crystalline or metamorphic rocks were regarded as owing their characteristic structure to their contact with other heated or so-called igneous rocks,—such as granite was supposed originally to have been, constituting the lower zone at least of the crust of the planet we inhabit.

For some time past, some of our most acute and practical geologists have more than doubted the old doctrines, and our own Sorby, by detecting the existence of steam-bubble cavities in granite, decisively proved that dry heat had not been the cause of its crystalline change. Dr. Rubidge, who has done so much good geological work at the Cape of Good Hope, also years before threw doubts on the heat-origin of the changes exhibited by the metamorphic rocks, by stating the occurrence, in the district of Port Elizabeth, of intercalated metamorphosed strata with unchanged sedimentary beds above and below them. Such examples have since been from time to time not unfrequently timidly recorded, but they are now being more boldly noticed. Dr. Hitchcock, very lately speaking of the granites of Maine, in the Northern States of America, regarded the old theory that granite was once melted matter thrust into every crack of the overlying strata as erroneous, and substitutes the aqueo-igneous explanation of a plasticity of the original materials by means of steam, the primal structure of the rock being thus obliterated, and a new crystalline condition induced. He thinks that granite may thus have been formed out of schists, and these originally from shales and sandstones, and contends that it is "only an example of metamorphism carried to its utmost limit—carried far enough to obliterate all traces of stratification, foliation, and lamination." Observation, he further claims, shows that granite does not always constitute the axes of mountains, but that it lies between strata, and instead of having been the agent by which they have been lifted up, it has partaken of the general movements which have resulted from general causes. In York and Oxford counties, in Cumberland, and Franklin, he notices the intermixture of granite with bands of sedimentary strata, and constantly speaks of it as "comporting itself like a stratified rock." That of Buckfield is mostly in the form of large beds and veins, and at Woodstock mica-schist is seen lying beneath it. Again, in the south-eastern counties of Maine, granite at the south end of Bluehill Neck, overlies strata of gneiss and mica-schist; and in the Kennebec region it is said that in one of the Hallowell quarries there are twenty-six different sheets, varying from eight inches to four feet in thickness, and that "these sheets are arranged like strata." In Canada, too, even the granites of the Lamentian and Lower Silurian age appear in every case to be indigenous strata altered *in situ*, and

still retaining evidences of their former stratification. These instances might be greatly multiplied not only in the American States, but by numerous examples in Europe, and probably by some in our own islands. Indeed nowhere is there any evidence of the hypothetical granitic substratum which, in even not yet very ancient treatises on Geology, we were taught to believe constituted the "backbone of the earth." Even one such example of interstratification would have gone far to throw a doubt upon the purely igneous origin of granite, but when instances become so multiplied the doctrine seems no longer tenable. Dr. Hitchcock argues forcibly against it. The dry heat, he contends, that would be required to keep granite melted must be intense, for it resists the most powerful blast-furnaces, and even if, as melted matter, it were injected in close contact with the cold walls of fissured rock, it must have cooled before it had time to penetrate all the narrow crevices in which it is found in the form of veins. Again he urges that, if crystallized from such fusion, the quartz would have been consolidated and crystallized first, because it is less fusible than the mica and feldspar; instead of which its condition in the structure of granite shows it to have been the last consolidated of the ingredients, for if anyone examines a piece of granite, he will see the crystals of mica and feldspar are often perfect, while those of quartz are never so. The quartz is always in the amorphous state, and the sharp crystals of mica and feldspar seem to cut into it, as is beautifully seen in graphic granite—an appearance which cannot be accounted for in any other way than that the mica and feldspar crystals were formed first, and that the quartz subsequently filled up the interstices. But such an admission is fatal to the doctrine of a cooling down from fusion by dry heat because, in that case, the quartz should have been, as we have said, the first to crystallize. Moreover, that granite contains not a few hydrated minerals, or such as contain water in their composition, is another fact telling also against the old opinions.

In the matter of metamorphic rocks Mr. Sterry Hunt has also been continuing those valuable theoretical and practical researches of which he gave us two instalments in 1858 and 1859. Those articles were remarkable for the great ability of his attempts to indicate the ages of granites by the amounts of soda or potash they contained, and during the present year he has given to the world another elaborate paper, read before the Dublin Geological Society, on the chemical and mineralogical relations of the metamorphic, or, as they have been as commonly called, the crystalline primitive rocks. It is not indeed so very long since all rocks of this character were included in the common designation of primitive, and were considered to belong to a period anterior to all the fossiliferous formations, and indeed to the existence of life, either vegetable or animal, on our earth. To express this idea, the term "azoic" was invented, while "palæozoic" was given to the Silurian rocks, as containing the supposed first traces of animated existence, or the "oldest life-forms," on our planet. Some geologists still consider the Lower Silurian or Cambrian zone to be the first burial-ground of organic remains, and that no previous creation of animated beings or vegetation had taken place. Not only, however,

do the imperfectness of the animal series, and the superior organization and degrees of development of the fossil genera and species met with in the lowest of the palæozoic rocks, as they are at present restricted in their downward horizons, militate against such a view by indicating the *previous* existence of zones of *previous* creations, and causing the reflective mind to regard these earliest palæozoic fossils as only the shreds and patches of still earlier life-garments of our earth, but they seem also to make the inquiry lack the aid of the chemist and mineralogist to tell us whether, in the present altered state of such rock-masses as are older than the palæozoic beds, there can be detected in the component materials any ingredients which owe their presence to the former existence in those masses of organic remains.

It is exactly with this question that Mr. Sterry Hunt has occupied himself, and has made some excellent attempts to ascertain whether, in the absence of organic remains, or of stratigraphical evidence, there are any means of determining, even approximately, the geological age of a given series of crystalline stratified rocks—in other words, whether the chemical conditions which have presided over the formation of sedimentary rocks have so far varied, in the course of ages, as to impress upon such rocks any marked chemical and mineralogical differences. To some extent it does appear possible to work out such a problem in respect to definite cases, although as yet no one could see the way to the generalization of a rule; indeed, in the ever-variable and divergent conditions of our planet's surface, and the different combinations and oppositions of the atmospheric influences which have been, through all periods, carrying on their effects around it everywhere, it seems impossible this ever should be accomplished. To arrive at any such indicative result in the case of unaltered sedimentary formations could not be accomplished without multiplied analyses, and even then the conclusions might not be absolute. It is different, however, when chemical or mineralogical changes have set in, for the natural affinities of some elements for others render definite the results of such combinations, and so we find that the crystalline minerals which are formed are definite in their composition, and vary with the chemical constitution of the sediment from which they were derived. Therefore it is that Mr. Sterry Hunt thinks these crystalline minerals of the metamorphosed rocks may become to a considerable extent, to the geologist, what organic remains in the unaltered rock are to the palæontologist—a guide to geological age and succession. The feldspars, for example, composed mainly of silica and alumina, combined with the silicates of potash, soda, and lime, do, in their spontaneous decomposition, part with the latter ingredients, and there remains behind, as a final result, a hydrous silicate of alumina, which is kaolin, or clay. Now, where potash and soda feldspars are associated, it has been repeatedly observed that the soda-compound is much more readily decomposed than the potash-compound, and that the soda-feldspar becomes perfectly friable, and fit for a further reduction into clay before the orthoclase, or potash-feldspar, has been altered at all. The result of combined chemical and mechanical agencies acting upon rocks containing quartz, with orthoclase and such soda-

feldspars as albite and oligoclase, would be thus a sand-compound of quartz and the less destructible potash-feldspar. The mechanical agency might be air or water; if the latter, there would be found suspended in it a fine clay, consisting mostly of the partially decomposed soda-feldspar. Now this process of destruction is evidently one which must go on in the wearing away of rocks by aqueous agency—just the agency which is the most important in such inquiries as the present, because most intimately associated with the deposition of the sedimentary rocks. It is easy to see how, by such partial destruction of the primal rocks, quartz is for the most part wanting in those which contain a large proportion of alumina, while it is abundant in those in which potash-feldspar predominates. So long as this decomposition of alkaline silicates is sub-aërial, both the silica and alkali are removed in a soluble form. But as immense quantities of undecomposed fragments of the primal rock are detached by atmospheric causes, and carried down to the sea, which acts upon these with more power even than upon the surfaces of the rock directly exposed to its influence, the process is often sub-marine and beneath the sea-bottom in the midst of sediments containing the carbonates of lime and magnesia. When the silicate of soda is, under such circumstances, set free, it reacts upon those earthy carbonates, or upon the chlorides in the sea-water, and forms in either case a soluble soda-salt, and insoluble silicates of lime and magnesia.

The sources of the carbonates of lime and magnesia in sedimentary strata, have been the decomposition of silicates containing those bases, such as lime-feldspar and pyroxene, and the action of the alkaline carbonates formed by the decomposition of feldspars upon the chlorides of lime and magnesia originally present in sea-water, but which have been by this process in subsequent ages, in great part replaced, by the resulting chloride of sodium. A curious result as showing the sea to have not been originally as salt in the primeval era as it is at the present epoch, and giving, if the total could be ascertained, the clay or aluminous silicate of the earth's crust, as a measure of not only the quantity of salt added to the primitive ocean, but of the amount of the carbonic acid removed from the air, and of the carbonates of lime and magnesia precipitated. As the coarser sediments in which quartz and orthoclase prevail are permeable to infiltrating waters, their soda, lime, magnesia, and oxide of iron will be gradually removed, leaving at last only silica, alumina, and potash —the elements of granite. On the other hand, the finer marls and clays, resisting the penetration of water, will retain their soda, lime, magnesia, and oxide of iron, and having an excess of alumina, will by their metamorphism give rise to basic lime and soda-feldspars, to pyroxene and hornblende—the elements of diorites and dolerites. In this way, the long-continued operation of chemical and mechanical causes would naturally tend to divide all the crystalline silico-aluminous rocks of the earth's crust into two types, exactly corresponding to the two classes of so-called igneous rocks, the trachytic and pyroxenic, which geologists have supposed to have been derived from two distinct imaginary magmas beneath it. When, however, ordinary

sedimentary strata have been rendered crystalline by metamorphism, their future alterability becomes difficult, because their permeability to water is so enormously diminished, and it is not until they are once more broken down to the condition of soils and sediments, that they become again subjected to such important chemical changes as we have described. Hence, the mean proportions of alkali and alumina in the composition of the clay sediments of any geological period will depend not only upon the age of the formation, but upon the number of times its materials have been broken up, and the periods during which they have remained unmetamorphosed and exposed to the action of infiltrating waters. Such are the general principles which in this excellent paper Mr. Hunt brings to bear upon the actual state of the metamorphic rocks of Canada from the Carboniferous to the Lower Silurian, and down to the azoic rocks and granite, even the veins of which he regards as formed like metalliferous veins by aqueous deposition in fissures.

The Sixth Annual Report of the Maine Board of Agriculture* recently circulated, presents a feature not so common in this country as it deservedly ought to be, an association of geological investigations with the practical pursuit of agriculture. Even in the first few pages on the application of fish-manure, and where we should have little expected it, we find practical hints from the geologist. Commenting on Mr. Bruce's endeavour to introduce this to us very objectionable and disgraceful appropriation of the most extensive source of animal food which nature supplies to mankind, Mr. Sterry Hunt recommends the combination of the fish-manure with calcined shale for the purpose of driving away insects from the plants to which it is applied. Distilling a black bituminous shale from Port Daniel at a red heat, the disengaged vapours were passed through a vat containing the fish, which by the continuance of the heat were ultimately reduced to a pulpy mass. The calcined shale, ground to powder, was mingled with this; the whole being then dried. Experiments made with the manure are reported to have given satisfactory results; it might be well if English agriculturists should pay some attention to the poorer kinds of bituminous shales which are met with in the British Isles, and even the refuse of the richer sorts, such as the Kimmeridge and the Glasgow shales, which have been used for making gas, might be in this way turned to a useful and profitable account, not necessarily for mixing with fish-manure, the use of which we have strongly deprecated, but for commingling with many other classes of manures, as the chief efficacy calcined shale possesses against noxious insects appears to be in the presence, or perhaps in the odour, of the bitumen it contains; for it is known that coal-tar applied to the interior wood-work in greenhouses has the effect of expelling those unwelcome intruders. Such bituminous sandstones as those of Caithness, might thus be turned to profitable account, and there are other

* 'Sixth Annual Report of the Secretary of the Maine Board of Agriculture.' Augusta: Stevens and Hayward, 1861-2.

rocks in various parts of our island, which, although not sufficiently rich for gas-making, contain quite sufficient bituminous ingredients for agricultural purposes, particularly the enormous beds of shale which are at present left untouched in our coal-pits. But it is not in incidental suggestions like this, valuable as they may be, that this Report shows in the strongest light the important relations existing between the geological structure of a country and the farming operations carried on upon it. So high has the Board of Agriculture of Maine considered the advantage of such knowledge, that it has directed a special survey to be made of the whole State, "believing that such a survey, ably conducted, would greatly tend to develope and improve its agriculture;" and urging at the same time "that the utility and value of such explorations are no longer doubtful." This preliminary Geological Survey has been executed under the direction of Mr. Charles H. Hitchcock, of Amhurst, with Mr. Goodall, of Saco, as chemist, and Mr. Houghton as mineralogist. By them the seaboard from Saco to Calais was explored, and excursions made into the interior, and to the islands; next through the north of Washington County to Holton, and thence to Bangor. Subsequently up the Penobscot river, down the Alleguish and St. John river to Woodstock, through the iron and slate region of Piscataquis County, the country around Moosehest lake and the Penobscot river. By these explorations and the use of the valuable observations previously made by Dr. Jackson of Boston, a sufficient idea of the geological structure of the slate has been obtained for the construction of a general map, to serve as a basis for future systematic and more thorough explorations. It is not our intention to follow through the report of this, as far as it goes, excellent survey, but to gather rather from it such new or remarkable purely geological phenomena, as may be worthy of particular notice. One of these is a condition of the pebbles in a conglomerate bed on the northern border of Washington County, which is very remarkable. The inclination of the strata is some 65° easterly; the strike being N. 8° W. The layers are sometimes contorted, and numerous narrow perpendicular veins of quartz cut across their bedding. But the peculiarity of the conglomerate consists in the distortion and curvature of the pebbles it contains, the general appearance of which is illustrated in the accompanying sketch. They appear as if they had been drawn out, curved, and pressed together by the forces to which they had been subjected. Mr. Hitchcock considers there is no doubt of these pebbles having been curved since the consolidation of the rock in which they are embedded; and even goes to the length of asserting, that such elongated pebbles have been changed into the siliceous laminæ of talcose and micaceous schists, while the cement has been converted into mica, the talc of talcose schists, and feldspar. To effect the change of form of the pebbles, according to Dr. Hitchcock's views, the substances of which they are composed require to have been brought into a soft or yielding state like moistened

clay, and then to have been contorted under the application of force or pressure; while to effect their still greater alteration into the laminæ of schists, he looks to the further continued action of chemical changes amongst the heterogeneous sedimentary materials in selecting and combining the different mineral atoms in their proper proportions to form the new crystalline masses.

Letting alone this last topic, and confining ourselves to the phenomena of contortion only, if these pebbles were of clay, we could understand their being softened; but if they are of limestone, sandstone, slate, or flint, it is very hard to believe they ever were softened after they were once solidified. The phenomenon is, however, exceedingly remarkable, and not yet perhaps clearly explainable. It would seem to belong to the same class as the Nagel-Flue of Switzerland, so successfully investigated by Mr. Sorby, or as the nodular bands of limestone in the Wenlock Formation, to which attention has been drawn by M. La Touche and Mr. Salter. If anyone examines the ordinary condition of a conglomerate, or the nature of a sea-beach, the more or less rounded pebbles will be found simply piled one upon the other, very rarely are any elongated or flat, except when the pebbles are of slaty-rocks, and never bent unless they happen to be the fragments of naturally-curved strata. In no case are there any corresponding lines of contortion, such as shown in the woodcut, which represents a section of the Weston Conglomerate, in which the pebbles are drawn out and flattened, and compared by Dr. Hitchcock to spheres of clay pulled out into prolate-spheroids; and the pressure of an immense weight might, he thinks, be so continued as to elongate a pebble of clay into the resemblance of a lamina of quartz in gneiss. He makes intelligible the nature of the Weston Conglomerate by supposing that amongst many balls of clay some were plastic and some hard, and that these were then subjected to such a pressure as should pull out and flatten all the plastic ones, which would thus have their forms modified by the unyielding ones, the plastic pebbles fitting on the solid ones like a cap on the human head. "We find," he says, "among the distorted pebbles cases of this nature. Some pebbles have been more plastic than others, and the results are: indentations of the harder into the softer ones, curves around the hard ones, or the fitting of one into another like a ball into its socket, or the ends of the elongated pebbles may only fit upon each other to economize space"—as in the woodcut.

An example of the first stage of the distortion of pebbles is to be seen near Newport, R.I. The lower carboniferous conglomerate at Alms House, north of that city, is in a normal state, and consists of a mass of loosely-cemented cobble-stones, from an inch to six inches in diameter, all round or spheroidal; but two miles further, at Purgatory, there is another mass of conglomerate, nearly of the same age, having the pebbles much elongated in the direction of the strike, flattened, and often indented, "by being pressed one into the other;" they are sometimes a good deal bent, occasionally in two directions, the whole being cut across by parallel joints or fissures, varying in distance

from one or two inches to many feet. The cement is very meagre, and consists of talcose schist, containing crystals of magnetite: the pebbles, however, are firmly adherent. In small flexures of the strata, Dr. Hitchcock has observed the elongated pebbles bent at the same angles.

The part of the 'Philosophical Transactions of the Royal Society,'* containing Professor Owen's valuable and admirable Report on the extraordinary bird-remains from the lithographic limestone of Pappenheim—the *Archæopteryx macrorus*—has been published during the past month, and the full particulars of the memorable description which excited such attention at Burlington House, in the November of last year, are now before the world. It appears to have received little alteration or emendation, as far as our memory will permit our judging, since the time of its first reading, when the completeness and lucidness of the account were features which prominently struck all hearers. The first evidence of bird-remains in the Solenhofen-beds was, as it is well known, the impression of a single feather, described and figured, with his characteristic minuteness and care, by Hermann von Mayer, in the 'Jahrbuch für Mineralogie,' under the title of *Archæopteryx lithographica*, and although it is most probable that the class of birds was represented in the Solenhofen age by more than one family, Professor Owen has retained the generic appellation of Archæopteryx for the present specimen. As the reptilian pterodactyles of the lithographic stone differ in the length of their tails—some having extremely long ones, as the *Ramphorhynchus longicaudus*, and others scarcely any, as the *Pterodactylus crassirostris*, so we may expect to find similar differences in the strange birds which lived in those days; and just as the original appellation of Griphosaurus given to it by Wagner, under the idea of its being a feathered reptile, has been changed to Archæopteryx, it is not by any means certain that the generic term may not yet have to be again altered.

Professor Owen's paper commences with an account of the circumstances under which the specimen was found and those under which it was acquired for our national collection. The exposed bones in the specimen are then named, and one after another compared with those of recent birds of different species, and the corresponding bones of various fossil pterodactyles, a comparison requiring unusual care and accuracy on account of the previously supposed reptilian characters of the singular remains. By his examination and comparison Professor Owen has proved the general ornithic nature of the fossil—a conclusion which must be henceforth adopted; although there are some points which cannot be settled by the present relics, and which may hereafter, when fresh examples revive the subject, give rise to some important considerations. A magnificent lithograph of natural size is given of the principal slab and its contents, even to its ripples and surface-markings, by Mr. Dinkel, who has as conscientiously done his duty in

* 'Philosophical Transactions of the Royal Society of London,' vol. cliii. part 1, 1863.

as faithful a representation as it is in an artist's power to attain. But neither Mr. Dinkel nor any other artist can free himself from a bias of ideas. The hand will follow the mind, and given the notion of a fish's head, the pencil will involuntarily portray the resemblance in figuring the object to which the resemblance is assigned. When Professor Owen first described the Pappenheim specimen, he made no mention of what has since been described by Mr. Mackie as the brain or cast of the cerebral cavity of the skull, nor of certain osseous relics which in the present publication are referred to as a "premaxillary bone, and its impression resembling that of a fossil fish." And yet these objects are perhaps among, if not actually, the most important of all the fossilized remains. The nodule representing the brain, it is admitted by the Professor, may be, as suggested by Mr. Evans, "part of the cranium with the cast of the brain of the Archæopteryx;" but of the so-called fish-head he makes no other remark than the quotation above, "resembling that of a fossil fish." Nor do we blame his reticence. Every word Professor Owen says carries weight, and the last-mentioned object is certainly in so obscure a state that no one, without further illustrative fossils, could by any possibility determine what it is. It would be discordant with all our present knowledge to find a bird's beak containing teeth in sockets, yet that would not be more extraordinary nor more out of all comparisons with living things than a long tail such as the Archæopteryx undoubtedly possesses. Yet such a toothed bill may be possible. After many days' careful study and comparison we could not convince ourselves that this object was a fish's jaw, nor could we find evidence enough to assert that it was a bird's beak with teeth; but it certainly has, as it lies in the slab, as much likeness to a beak as to a premaxillary, and as there is not a fish-scale nor a fish-bone in the whole slab, nor in its counterpart, nor a speck nor portion of a fish in either, it is as possible for this object to belong to the Archæopteryx as to any other creature.

The general ornithic nature of the fossil is, as we have already said, indisputable, but not so positive do we think can anyone be as to its exceptional characters. If the Archæopteryx had in its long vertebrate tail, one character so exceptional as not to be matched by any existing or any other fossil bird, it may have had other characters as exceptional; and although we should say that no bird that preened its feathers would have teeth, yet the beak of a bird is but a modified mammalian jaw, just as the whole structure of birds is a modification of the mammalian type; so it is not without the bounds of possibility that a bird's jaw may be in such a state of development as to retain some traces of teeth. Nor can we be certain, it seems to us, that there are no reptilian affinities, or, at least, resemblances in the structure of the wings. Had the manus of Archæopteryx been adapted for the support of a membranous wing, the extent to which the skeleton is preserved, and the ordinary condition of the fossil Pterosauria in the lithographic stone, render it almost certain, as Professor Owen properly observes, that some of these most characteristic long slender bones of the pterosaurian wing-fingers would have been visible

if such had existed in the present specimen; and besides this negative evidence, the positive proof of the bird-like proportions of the pinion, and the existence of quill-feathers, sufficiently evince the true class-affinity of the Archæopteryx. We are, however, in ignorance as to the manner in which those singular wing-hooks were attached to the main bones of the wing, and of all the comparisons which Professor Owen has made with the spur-winged birds, such as the *Merula dactyloptera*, *Anser gambensis*, *Parra jacana*, *Palamedea cornuta*, and *Megapodius*, there are none, we believe, which give us a single illustration of the same character of organization as is exhibited by the claw-hooks in the Archæopteryx. Indeed, Professor Owen admits that in this respect, it differs from every known bird in having "two free unguiculate digits," *i. e.* the wing-hooks, "in the hand," and that "these digits in the slenderness of the penultimate phalanx do resemble the unguiculate digits in the hand of the Pterodactyle." But it is true, as Professor Owen continues, that "the claw has not the characteristic depth or breadth of that of the Pterodactyle; and there is no trace of the much lengthened metacarpal and phalangial bones of the fifth digit, or peculiar wing-finger of the flying reptile." We doubt, however, if the wing-claws of the Archæopteryx are comparable with the spurs of the jacana, or of the screamer; and we are not aware that the skeletons of either are obtainable in this country for comparison.

These are questions, however, which it is judicious of the Professor to avoid until there is sufficient evidence collected to warrant, if not a decisive, at least a reliable opinion. It is quite a different thing for us to point them out, that the importance of obtaining further illustrative specimens may be borne in mind.

VI. MICROSCOPICAL SCIENCE.

As the advance of all physical science depends in a great measure on the degree of perfection of the instruments with which it is studied, we propose devoting this, our first article on the progress of Microscopical research, to a brief exposition of the improvements that have been recently made in the construction of the instrument. Our next article, on the other hand, shall be devoted to a review of the modern standard works on the Microscope, and its mode of application; and then having, as it were, set our house in order, we shall be prepared in our subsequent Numbers to enter directly on the true object of our work, namely, to keep our readers *au courant* with the progress of microscopical inquiry.

Fortunately for us, we do not at the present day require to say anything in support of the claims of the microscope to public attention. Scientific men have unanimously decided in its favour, and although, among the general public, there are still individuals to be encountered who regard its teachings with distrust, their number is

day by day becoming more and more limited, as the object and powers of the instrument are becoming better and better understood. Many false doctrines have no doubt been promulgated in consequence of the employment of the microscope; but for one that depended on the imperfection of the instrument, a thousand arose from a defect in the observer. We are even forced to admit, that there are still amongst us, men who without any previous training, or special aptitude for microscopical research, damage the cause in which they are volunteers, by insisting upon publishing the result of their labours, and loading our journals with false data and erroneous theories; which although perhaps perfectly harmless in themselves, nevertheless clog the chariot wheels of progress. And what is still more unfortunate, these would-be discoverers often become the worst enemies of the microscope; for, as in the course of time they see their cherished facts and theories one by one swept away, instead of attributing this their misfortune to its proper cause, they seek to turn the blame against the instrument, which they imagine misled them. In a word, the enemies of the microscope, at the present time, are only to be found, either among those who do not possess an instrument, or possessing one, do not know how to use it. Remember, we do not consider that a man knows how to employ the microscope because he can demonstrate the presence of infusoria in a drop of water, exhibit muscular fibres on prepared slides, or focus photographs of the Royal family, not bigger than a pin's point; for nine out of every dozen of men who can do that are unequal to the preparation and demonstration of a piece of simple cellular tissue. If the microscope fails to assist such as we have just been describing, that is no reason why it should fail to assist others, even although they are not scientific men.

The education requisite for microscopical inquiry is a special education, attainable by every ordinarily educated man, either by means of books, or, what is still better, by oral instruction. In proof of this assertion we have only to look around us, and see in whose hands the microscope is now being turned to account, and we shall at once perceive that the employment of the instrument is no longer the monopoly of professional men. It has even passed through the second stage of its career, and after having for a time occupied the place of instructor of the idle hour to the amateur, has entered, in the hands of the commercial class, upon the third phase of its existence. The liquids we drink, the food we eat, the clothes we wear, have each been found to lie within its scope. Hence the microscope is to be met with in the office, in the warehouse, and in the shop. It is consulted in ascertaining the purity of flour, in revealing the nature of arrowroot, in unmasking the adulterations of coffee, and in innumerable other ways advancing the interests of trade. And it would prove even still more useful in its commercial capacity, if men would but refrain from seeking its assistance until they had exhausted the information attainable by the unaided eye; for the true object of the microscope is not to supplant, as too many imagine, but to extend our ordinary means of observation, and when so employed it never fails

to yield important information. It is not, of course, to be supposed from these remarks, that we would try to limit its field of usefulness, for our object is, on the contrary, to endeavour to enlarge it. The advice we give has, in fact, this object in view, and is simply that if, instead of directly placing an object under the microscope, the observer will first take the trouble to examine it carefully with the naked eye, he will find himself in a far better position to form a correct judgment of its nature on seeing it under the magnifying-glass, than if he had omitted previously to do so.

Having said this much regarding the observer, we must now turn our attention to his instrument. It is essential that it should be of good quality. When we speak of a microscope being of good quality, we do not mean that it should have handsome and elaborate brass work, for that part which is so attractive to the eye is the least valuable of the whole. 'Tis in the object-glasses—'tis in the lenses, that the real value of the instrument resides, and thus it was that scientific men so long preferred the low-priced insignificant-looking foreign microscopes of Nachet and Oberhauser, to the elaborately got-up English instruments. The foreign opticians sacrificed appearance to utility, while too many of our home manufacturers sacrificed utility to appearance. At the present moment, however, the British manufacturer is inferior to none, even in low-priced instruments, while, as is well known, his superiority in those costing from thirty guineas, and upwards, has never been matter of dispute.

Before speaking of the cheap instruments, we must first call special attention to the high-power object-glasses that have been recently constructed by Messrs. Ross, Powell and Lealand, and Smith, Beck and Beck, the value of which it is scarcely possible to overrate, seeing that there can be no end to discovery, so long as there is no end to instrumental perfection. In our opinion, the only boundary that human knowledge admits of, is that imposed upon it by the limited means of physical observation. Every additional magnifying power is, as it were, a new world gained.

The progress of science, therefore depends as much upon the mechanician, as upon the observer, for the acumen of the latter would fail to reach its goal, if unassisted by the skill of the former.

It will be recollected that Ross was the first to succeed in manufacturing an object-glass of $\frac{1}{12}$ of an inch focus, and that shortly afterwards Powell and Lealand overstepped him by producing a $\frac{1}{16}$, which, for the time being, was regarded as quite a scientific curiosity. The latter manufacturers have now, however, stimulated by Professor Beale, outstripped themselves, and actually manufactured a workable lens of no less than $\frac{1}{25}$ of an inch focus. Since then, Ross has improved his $\frac{1}{12}$, and Smith, Beck, and Beck have produced a $\frac{1}{20}$. Perhaps it will be better, if before describing the $\frac{1}{25}$, we first say a few words regarding the $\frac{1}{12}$ of Ross, and the $\frac{1}{20}$ as now supplied by Smith, Beck, and Beck. The advantages of the new $\frac{1}{12}$ are its having a large front distance with a maximum of real angle of aperture. It will work through glass the $\frac{1}{120}$ of an inch thick, and bear the highest eyepieces. These

improvements have been accomplished by employing specimens of glass which allow the minimum of thickness of media to be used. The powers with this objective range from 600 to 4,000. The $\frac{1}{20}$ is also so constructed, as to admit a large pencil of light, and at the same time leave a space between its front lens and the covering-glass of the slide sufficient to allow of the examination of ordinary objects. The $\frac{1}{20}$ magnifies with the three eyepieces, 950, 1,700, 3,100, linear; its aperture is 140 degrees; and the thickness of the covering-glass, to which it will adjust, is ·005 of an inch.

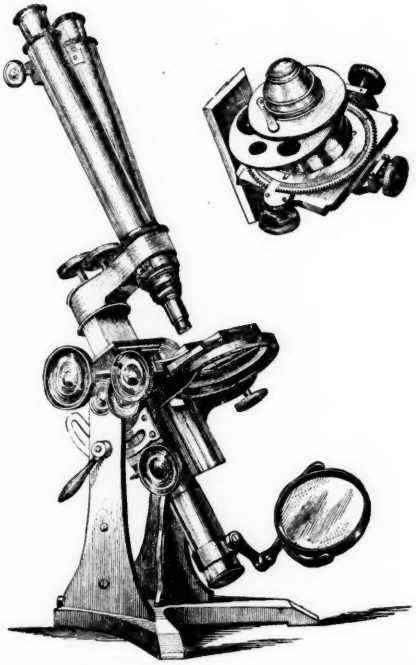
The $\frac{1}{25}$ of Messrs. Powell and Lealand, as we already said, was first made at the suggestion of Dr. Beale, and we can corroborate from personal experience the expression made use of by the jurors of the late International Exhibition, namely, that it is possible to see by its means evidences of structure which are under ordinary powers utterly undistinguishable. On looking at an object with the $\frac{1}{25}$, after having first used the $\frac{1}{4}$ of an inch, one is immediately struck with the great difference in size which it presents. The object looks six times as large as it did with the $\frac{1}{4}$ of an inch, and although of course the field is darker, it is not nearly so dark as one might be led to expect, considering that we are employing a magnifying power of 1,300 diameters.

In order to see objects distinctly with the $\frac{1}{25}$, it is, of course, necessary to use a good light; but it does not require that the light should be very much stronger than that ordinarily employed when using a quarter. The common microscope-lamp, and achromatic condenser, are all that is requisite for the purpose of illumination. Like Smith, Beck, and Beck's $\frac{1}{50}$, Powell and Lealand's $\frac{1}{25}$ object-glass is adapted to suit any English microscope, to be used with a covering-glass of ·005 of an inch in thickness, and to leave a sufficient space between the lower lens and the glass to admit of its being employed in the examination of ordinary objects. The $\frac{1}{25}$ consists, like all other good objectives, of eight lenses, two triplets, and one doublet. The front one, indeed, measures only ·025 of an inch in diameter, and to the naked eye looks like a small diamond in its setting. It is, however, a vast deal more valuable than a diamond of the same dimensions.

There is great difficulty experienced in the manufacture of these lenses; for they have actually to be ground under a microscope. This arises not simply because of their small size, but in order to enable the workman to keep the surfaces perfectly level, as a deviation of as little as one thousandth of an inch would give rise to both spherical, and chromatic aberration. To specify the particular class of objects for which the $\frac{1}{25}$ is adapted, is not our present purpose.

We have now to say a few words regarding the improvements that have recently been introduced into the construction of the large microscope stands. These have for the most part been devised by Mr. Ross, with the view of obtaining additional working room for the illuminating apparatus beneath the stage, in order to acquire the greatest possible angle for simple oblique illumination. This object has been accomplished, as will be seen in the figure, by reducing the

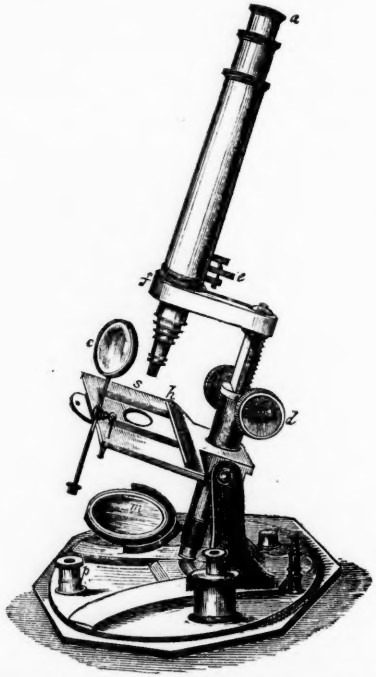
thickness of the mechanical and sub-stages. A still further improvement has been made by adding an additional tube, and thereby adapting the instrument to the binocular arrangement. Moreover, Mr. Ross has graduated the circular parts of both the upper and lower stages so as to enable the observer to use the instrument as a goniometer.



We shall now pass on to the consideration of our next head, namely, the diminished cost of instruments for the use of students and others.

At our public institutions where there are large microscopical classes, as, for example, at University College, London, and at the University of Edinburgh, the great majority of the students have hitherto been supplied with the foreign instruments of Nachet and Oberhauser, costing about 8*l.* each. Now, however, English opticians are cutting the ground from beneath the foreigner's feet, by producing really good useful instruments at similar prices. The most recently constructed microscope of the kind, is that just brought out by Parkes of Birmingham.

It is a handsome-looking instrument of the form represented in the accompanying woodcut.



This microscope is made entirely of brass, and is 16 inches high. At first sight, it looks like an instrument costing 18*l.* or 20*l.*, which is more than double the actual price. It is supplied with two powers of a quarter of an inch focus, two eyepieces, a polarising apparatus, a coarse and fine adjustment, a magnetic stage, a circular diaphragm, a double mirror, and a stage condenser.

The microscope is so constructed as to fit into a hexagonal box; the bottom of which forms the stand of the instrument, and into which are set the requisite apparatus. So, no sooner is the top of the box removed, than the microscope is found in its place all ready for use. The objectives and eyepieces are, as we have said, fitted into the stand round the instrument, so that they can be adjusted at a moment's notice, and in order that this may be done more effectively they are fitted with slips as well as screw attachments.

Moreover, the mahogany stand is polished, and has a circular groove round it, to receive the lip of a glass-bell jar, so that the box cover

may be dispensed with, except in travelling, and the instrument, with its glass shade, forms a handsome ornament to a room, while at the same time, it is always ready for immediate use.

If Mr. Parkes furnishes a quality of lenses to all his microscopes made on this plan, similar to those attached to the instrument we had the opportunity of seeing at University College, we must admit he will prove a formidable rival to foreign instrument makers.

There are still lower priced instruments, which are extremely well adapted for educational purposes, now being manufactured by Messrs. Highley, Pillischer, Baker, and Smith and Beck; but the consideration of these we must defer to a future occasion, and for the present turn our attention to the binocular microscope.

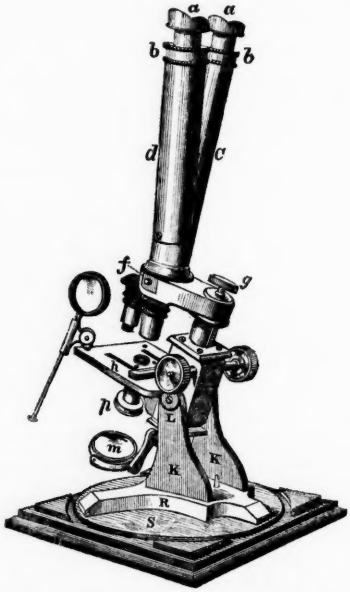
As is well known, the purpose of the binocular microscope is to remedy the difficulty in the way of correct observation, arising from our having to view an object with only one eye. Mr. Wenham, by a very simple contrivance, has accomplished this in a most satisfactory manner, at least, as far as low magnifying powers are concerned; there is still, however, room for improvement with respect to high magnifying powers. By means of a small prism mounted in a brass box which slides into the draw tube immediately over the objective, the rays of light proceeding from the object are reflected in two directions, which by means of a double body are conveyed to both eyes, and thereby give a stereoscopic view of the substance under observation. This is a most important point gained, when uneven surfaces are being examined, because it enables the observer at once to judge of the position, form, and relative distance of the various parts without altering the focus of the microscope.

So valuable, indeed, has this improvement been considered, that all opticians are now prepared to attach an additional draw tube and prism to any of the ordinary uniocular instruments, and thereby make them answer both purposes. For be it remembered, that the attachment of a binocular body in no way interferes with the employment of the instrument as a single-eyed microscope.

As it is impossible, in this short review, to describe all the varieties of binocular microscopes now placed before the public, we must limit our remarks to the one which we consider the most perfect.

The binocular, which we believe is most deserving of this title, is that just brought out by Mr. Collins (of Titchfield Street, Portland Place, London). It is constructed on the model suggested by Professor Harley, and contains all the recent improvements for combining rapidity of application, with simplicity in manipulation. Indeed, so far as the saving of time is concerned, we scarcely know how a change for the better could be devised. It possesses also the further advantage of having the apparatus so arranged as to render it a matter of difficulty to put it out of order. The whole apparatus of the instrument, prism, polariscope, stage condenser, objectives of both high and low powers, &c., &c., are attached to the microscope itself, and that, too, in such a manner as to enable the observer to place them in exact position without the turn of a single screw, or a moment's delay.

A glance at the accompanying woodcut will greatly aid in the understanding of this mode of arrangement.



The microscope, as is here seen, is fixed into the bottom of the mahogany box, which forms at the same time the stand. Round it, like the one previously described, which is in this respect made on Dr. Harley's model, a groove is run to receive the lip of a glass shade. The instrument itself is made of polished brass, and is eighteen inches high. The eyepieces are supplied with shades (*a*, *a*) to protect the eyes.

These are a great comfort to the observer when he is using the instrument for any length of time.

At the end of the transverse arm (*f*), is the box which contains both Wenham's binocular prism, and the analyser of the polariscope; and by merely drawing it a little out, or pushing it farther in, the instrument can be instantly changed from a binocular to a uniocular, and still further to a polarising microscope.

Immediately beneath (*f*) are the two objectives, a quarter, and an inch; so that in order to change the power, all that is necessary is to slide them backwards or forwards. Moreover, these are fitted with the universal screw, so that either of them may be detached, as in an ordinary instrument, and a $\frac{1}{8}$, a $\frac{1}{25}$, or any other power, put in its place at the option of the observer. The instrument is fitted with a coarse

and fine adjustment, and has the additional advantage of a magnetic stage, in the cross-bar (*h*) of which is a groove, in order that the observer may enjoy the luxury of applying a Maltwood's finder, as in large instruments possessing movable stages.* Beneath the stage is seen the polariser (*p*), fitted into the circular diaphragm.

The double mirror (*m*) possesses a triple joint, so that it can be applied obliquely in all directions. Indeed, as we before said, it is difficult to see how an instrument could be devised of a more simple, and, at the same time, so perfect construction at the price.

Having now given our readers an insight into the most important improvements that have been recently made in the construction of the instrument, we purpose in our next Number introducing to their notice, the various works on the microscope, and its mode of application.

VII. MINING, MINERALOGY, AND METALLURGY.

The Mining operations of these islands may be regarded as amongst the most important of our industries, taxing—as they do, to the utmost—the powers of man's endurance, and the resources of engineering science; requiring the boldest expenditure of an enormous capital, and adding nearly thirty millions sterling to our national wealth. Hidden in our rocks is the "hoarded treasure," but man, the magician with the wand of industry, brings it forth to-day and converts the valueless ores into valuable metals, which minister in a thousand forms to the necessities of human existence.

The subterranean explorations now in active progress in this country, claim the labours of above 300,000 Miners, independently of men, boys and women, employed at the surface. They task the powers of thousands of steam-engines in pumping the waters from the depths; in drawing the minerals from the mines; in lowering and raising the men; and in restoring pure air to those dark recesses in which the atmosphere is rapidly suffering deterioration from several causes.

At the present time there are upwards of 3,000 collieries, and not less than 1,000 metalliferous mines at work in the United Kingdom. The produce of these—in the more important minerals only—during the last two years, has been as follows:†—

	1861. Tons.	1862. Tons.
Coals	85,635,214	81,638,338
Iron Ore	7,215,518	7,562,240
Copper	231,487	224,171
Tin	11,640	14,127
Lead	90,696	95,311
Zinc	15,770	7,497
Pyrites	125,135	98,433

* Maltwood's finder can be obtained at Smith, Beck, and Beck's.

† These, and all the statistical returns given, are taken from the 'Mineral Statistics of the United Kingdom,' by Robert Hunt, F.R.S., which are published annually by order of the Lords Commissioners of Her Majesty's Treasury.

In addition to these, of ores of the metals, our mines give us Silver, Nickel, Cobalt, Tungsten, Antimony, Manganese, and others. Of earthy minerals we produce Barytes, Strontian, and Gypsum, independently of the Lime, Magnesia, Porcelain, and other clays; while the Salt districts of Cheshire and Worcestershire give us above 900,000 tons of Salt annually.

Gold must be regarded as an unusual product from British rocks, but the Quartz lodes in the vicinity of Dolgelly gave us of that precious metal, in 1861, 2,784 standard ounces, of the value of 10,817*l.*, and in 1862, 5,299 standard ounces, the value of which was 30,390*l.*

Nearly all the Lead ores of these Islands contain Silver, and from this source, by an interesting Metallurgical process, we obtained, in 1861, 569,530 ounces, and in 1862, 686,123 ounces of sterling Silver.

From the returns obtained by the 'Mining Record' Office, we learn that the values of the Metals produced from the ores of the British Islands alone, and Coals, were at the place of production—

In 1861 at 34,602,853*l.*
In 1862 at 34,691,037*l.*

In this rapid sketch, we endeavour to convey a correct idea of the importance of our Mining operations, without loading our pages with details, which may be consulted by all who are interested in the subject, in the publication already quoted.

Directly connected with our Coal-Mining, one question of the highest importance has been recently revived:—that is, the probable duration of our coal-beds. Sir William Armstrong, in his Address as President of the British Association, at the recent Meeting at Newcastle-on-Tyne, spoke as follows on this subject:—"By combining the known thickness of the various workable seams of coal, and computing the area of the surface under which they lie, it is easy to arrive at an estimate of the total quantity comprised in our coal-bearing strata. Assuming 4,000 feet as the greatest depth at which it will ever be possible to carry on mining operations, and rejecting all seams of less than two feet in thickness, the entire available coal existing in these Islands has been calculated to amount to about 80,000 millions of tons, which, at the present rate of consumption, would be exhausted in 930 years; but, with a continued yearly increase of two millions and three quarters of tons, would only last *two hundred and twelve years.*" *

Mr. Greenwell stated a few years since his opinion that "the Northern coal-field would continue 331 years." Mr. T. Y. Hall agrees in the main with Mr. Greenwell, and taking the annual consumption of the Newcastle coal-field at 14 millions of tons, he gives 365 years as the period at which this coal-field will be exhausted. Mr. Fordyce in 1860, supposing the drain upon this coal-field to be 20 millions of tons annually, says, "then at this rate of demand the coal-field would be exhausted in the course of 256 years."†

* Report of the Meeting of the British Association at Newcastle, 1863.

† See 'The Transactions of the North of England Institute of Mining Engineers,' and Fordyce's 'History of Coal, Coke, and Coal Fields,' 1860.

In the Report presented by the Coal Trade at the recent Meeting of the British Association, the rate at which the reporters suppose the exhaustion of this coal-field is going on in 1861, is given at 21,777,570 tons.* This quantity is above that which is given in the 'Mineral Statistics for 1862' (we there find 19,360,356 tons recorded as the quantity raised and sold; but the coal wasted is not reported, owing to the uncertainty of the returns obtained).

Mr. Edward Hull has devoted much attention to this important subject. He calculates that the total remaining supply of coal amounts to 79,843 millions of tons, and "that in the whole of Great Britain the supply is sufficient to last for upwards of a thousand years with a production of 72 millions of tons annually." †

It has been already shown that the general rate of exhaustion has exceeded this computation by twelve millions of tons. It is not, however, probable that there will be any long continuance of such a rapid increase. The progress of civilization has ever been a system of undulations, the maximum of elevation is reached, and the still onward wave subsides, the momentum acquired in its decline being the power by which it again rises to its highest level. Let it not be inferred from this that we suppose our commerce and manufactures to have reached their highest point. It is believed that a large extension is before us, but we argue, from the history of the past, that our progress will not be a system of continuous rise in the future. The question requiring the limits of time within which the coal-fields of these Islands will be exhausted has been hastily propounded, and no less hastily replied to. No satisfactory computation of the quantities of *workable* coal remaining in our several coal-fields has yet been made. Mr. E. Hull, in his work already quoted, has given the best existing information, but those most intimately acquainted with special localities, all alike pronounce the evidence to be incomplete. This is admitted, by the grant of a small sum from the funds of the British Association, to collect exact information on this point. The grant is so small, for the amount of work which is to be done, that nothing satisfactory can be expected from this assistance. The Government having at its command a trained body of men, of superior scientific knowledge, in the officers of the Geological Survey, with twelve Inspectors of Collieries, each man well acquainted with his own district, and a Mining Record office with its statistical returns, might, by a judicious arrangement, and a sufficient grant of money, determine the question within very small limits of error. This stock-taking would be a very important one, bearing as it does, on the future of every manufacturing and commercial industry, which has placed our country the foremost amongst the nations,—a position which we desire to retain. Referring, of course to their own field only, the Reporters on the Northern coal-field say, "Until further and more extensive explora-

* 'On Coal, Coke, and Coal Mining,' by Nicholas Wood, F.G.S., John Taylor, John Marley, and J. W. Pease, in 'History of the Trade and Manufactures of the Tyne, Wear, and Tees.' Spon: London, 1863.

† 'The Coal Fields of Great Britain,' by Edward Hull, B.A. Second edition. Stanford: London.

tions determine at what distance beyond the coast the greatest depression of the coal-beds will be found, we are completely at fault as to the quantity of coal lying underneath the sea. * * * * We have not yet reached the threshold of such a conjecture. We have not yet explored one square mile of this vast unknown space, or determined one of the many elements required in such an intricate and uncertain investigation." To a certain extent, these remarks will apply with all their force to other localities. The difficulties determining the existence of coal, and its quantity, under several unexplored regions are exceedingly great, and until opened out, it could only be approximately estimated. Still we cannot but think the concluding remark of the Reporters, that "such an investigation can be of no practical utility, and that the attempt for a vast period of time is, at the least, premature," is one induced, rather by the influences of commerce, looking only to the present, than by the broader spirit of philanthropy which embraces the future. It may not be out of place here to caution the less scientific of our readers from receiving, as in any way probable, that speculation which is echoed from book to book promising man that science will find, when coal is exhausted, some other source of heat and light, which shall be equally economical and as easy of application. If those speculative minds, who suppose the time will come when the constituents of water will be burnt, or electricity be made an unfailing producer of heat, would but carefully entertain the fact, that every form of physical force is the result of the destruction (*change of form*) of matter somewhere, they would be more cautious in promulgating their unsupported hypotheses. To burn zinc or iron in a voltaic battery to produce heat or light, must always be infinitely more costly than burning coal in a furnace.

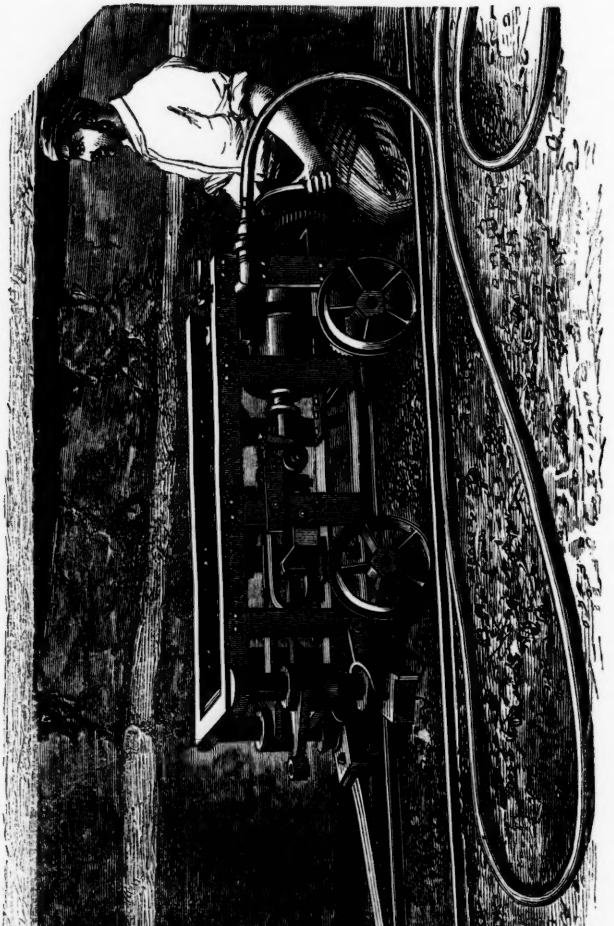
The lamentable catastrophes which from time to time occur in our collieries, awaken public attention, and excite the utmost sympathy for the sorrowing survivors. That there is a deep-felt desire to assuage the flood of misery which falls, tempest-like, upon a colliery village; and so far to improve the conditions under which the coal-miner labours, as to render the risks less imminent to him, is proved by the manner in which money was poured into the Hartley Fund. After some delay, the large sum which remained unexpended, after every necessary want had been satisfied amongst the widows and orphans of those poor men who perished so miserably in that Colliery, has been distributed to other districts for the purpose of forming the nucleus of local funds to meet such exigencies as may unhappily arise. The public expression of feeling is loud, it will be heard and attended to; but, independently of the impulse which is due to this voice, it must not be forgotten that numerous minds are, and have been silently and earnestly at work, aiming to improve all the conditions of our collieries, and so to render accidents less common.

We have lately, at the Morfa Colliery, in South Wales, had an explosion of fire-damp, by which 39 men were destroyed. This serious accident occurred in a colliery remarkable for its very excellent arrangements. The works were carried on under the most skilled colliery engineers; the ventilation was excellent; locked safety-lamps

were always used; and the strictness with which a well-devised code of rules was enforced appeared to secure this colliery from accident by explosion. Yet, when least expected, the fire-damp accumulates, and mysteriously it is fired, sweeping away in a moment 39 men, and strewing wreck around in its deadly progress. This sad accident should teach us that we must not suppose we can, by any skill or care, secure absolute immunity from casualties of this class. In all probability the Morfa explosion arose from a sudden outburst of carburetted hydrogen gas, attended with a fall of the roof, by which the wire gauze of a safety-lamp became broken. It is important that a record should be prominently made of the fact, that the proprietors of this colliery, the Messrs. Vivian, refused the aid which the public readily offered, and that they take upon themselves the burthen of supporting the widows and orphans of those who perished in their employment. Knowing the imperfections of human nature, and the power exerted by selfishness over the better feelings of the heart, we are persuaded that both master and man would be permanently benefited by a legislative enactment, rendering it imperative that the Colliery proprietor should be responsible for the maintenance of the widow and the child of the collier, who has perished by accident in his pit. With such a provision, a more searching system of inspection would be introduced; the workings would be kept in better order; rules would be more rigidly enforced; and, as a consequence, the coal would be obtained in better condition, and at less cost, than at present. Beyond this, the Colliery proprietors would speedily protect themselves by forming funds to meet the exigencies as they arose. A course of this kind is the only one left for trial: there is surely philanthropy enough in this Christian land to force on the experiment.

In nearly every division of human labour, some mechanical power has been introduced for the purpose of relieving the labourer from the constant strain made upon his muscular system. The coal-hewer has not, however, been in any way assisted. With the primitive pick and the ancient wedge, he has been compelled, often under the most trying conditions, to "get" the coal. This state of things may be accounted for by the circumstance that Mining work is performed in the deep and dark bowels of the earth, where there is little to attract, and much to repel, such minds as usually give birth to appliances of physical force. The subject has not been, however, entirely neglected. So long since as 1789, a patent appears to have been granted for improved machinery to be used in getting coal, and since that time many plans have been proposed, and some of them patented, though none have been successfully applied. The first machine which has been found capable of taking its place in the regular business of coal-cutting is one belonging to the West Ardsley Coal Company, Messrs. Firth, Donisthorpe, and Bower. This machine has been in regular work during the last twelve months, and it appears to be admirably adapted to the purpose for which it is contrived.

The Machine—shown on the adjoining plate—is carried on a cast-metal frame of great firmness, the size and weight varying to suit the condition and thickness of the bed of coal to be operated upon. An



The Ardsley Company's Machine

Engine is mounted within this framework: it is actuated by compressed air, and so arranged as to give the blow of the pick or cutter, either by the *pull* or the *push* of the piston. Almost any form of engine is applicable, but that which is employed with advantage in practice at Ardsley Colliery, is the oscillating cylinder principle, whereby is obtained compactness of form and diminished friction in the working parts. The whole is carried upon wheels with flanges, sometimes single and sometimes double, as may be required by the nature of the work. It is propelled backward and forward by a wheel and screw, or a ratchet and pawl, which is fixed on one side. On the other side is the valve-lever to regulate the admission and the emission of the air, and the stroke of the piston when the Machine is at work; the man in charge of it moves the ratchet-lever, which is connected with the gearing of the under-carriage, and thus pushes up the carriage on the tram, a distance equal to the cut of the previous blow; and so moves on to the end of the "bank," or working face of the coal. In seams of three feet, or upwards in thickness, the man may sit on a movable seat fixed at the end of the Machine, but in thin seams this cannot be done, and he has to kneel on a truck running on low pulleys or rollers which travel in the rear of the cutting-machine.

The cut, or groove of the coal, made by hand-labour, is a triangular opening varying in size according to the hardness and nature of the coal, but averaging from 9 to 12 inches. In firm coal the machine makes a cut which is not usually more than 2½ inches' opening, and the under-cut is taken 3 feet into the coal. The Ardsley Coal Company state that the coal is obtained in a better condition by machine, than by hand cutting, so much so that about 1*s.* a ton more can be obtained for the coal, on the yield of the seam.

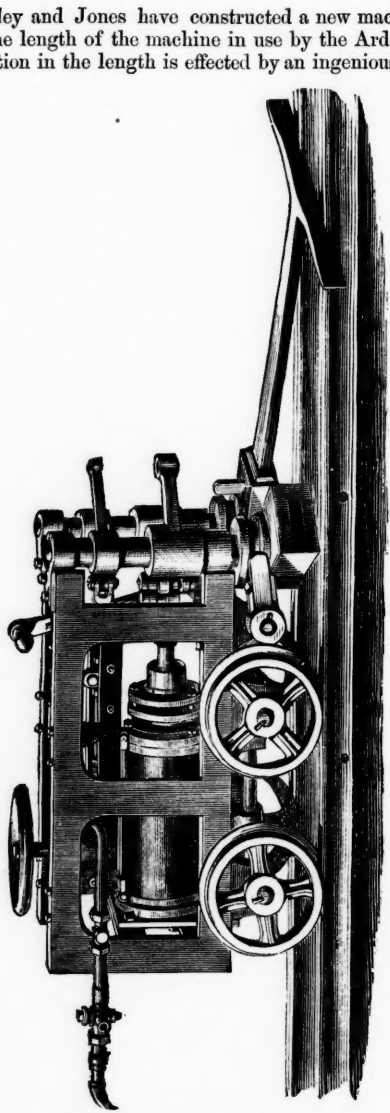
A matter of more importance than this is urged by the proprietors, *viz.* the diminished risk to the persons and lives of the employed.

Numerous lives are lost by falls of coal. It will be well understood, that, if the miner has made an opening in the lower part of the coal, which shall be 12 inches wide on the face, and the superincumbent mass of coal should by its weight fall, much care will be required on the part of the workman to keep himself harmless. Often, when working in a constrained position, the coalhewer, unable to relieve himself from the falling masses, is crushed to death.

By the machine work there is much less liability to this kind of accident. The groove being narrow can be spragged with ease and system, and a slip in the coal only closes up the groove. In ordinary cases the coal is not pushed out; but, if it does come forward, there is little danger to the workman, because he can readily get out of the way, and if it catches the machine but little injury is done. There are some technical advantages, beyond those named, which need not be noticed in this Journal.

The length of the coal-cutting machine which we have described, has been thought by some to be a disadvantage. Difficulties are said to have arisen when it was required to be taken round the short elbows, and the abrupt curves, which often occur in a colliery. To obviate this

Messrs. Ridley and Jones have constructed a new machine, which is about half the length of the machine in use by the Ardsley Company. This diminution in the length is effected by an ingenious arrangement,



Ridley & Jones's Machine.

the connecting rod to which the pick is attached, acting as a substitute for the piston, in this way the required length of stroke is obtained, as it were, within the cylinder itself.

This machine is very small and compact, being two feet two inches high, and three feet long, the pick being two feet six inches in length. As in the former case a man and a boy attend the machine in its progress along the ordinary tramway of the colliery.

The following diagrams will render clear the difference between the two machines. Fig. 1 represents the old patent arrangement: *a* is the cylinder, *b* the piston, *c* the piston rod, *d* the connecting rod, *e* the crank or lever. Fig. 2 represents the new patent trunk arrangement: *a* is the cylinder, *b* the piston, *c* the trunk, *d* the connecting rod, *e* the crank or lever.

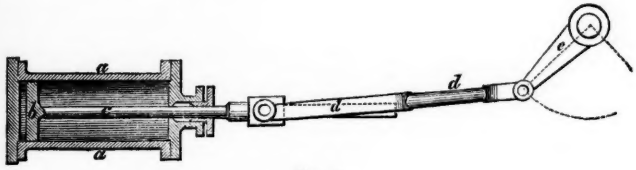


Fig. 1.

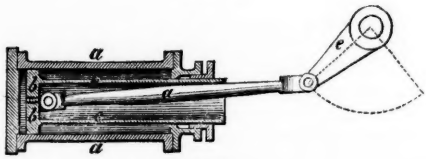


Fig. 2.

Either of these machines is guaranteed to be capable of undercutting a seam of coal to the depth of three feet, and to the length of 150 yards, along the face of the coal, in the space of eight hours. These machines can be worked either by compressed air or by steam. At the Ardsley Pit, air has been employed, and the experience of eighteen months confirms its advantage over any other motive power, for this purpose. The air is pressed into a receiver on the surface, by an ordinary steam-engine, to a pressure of from 45 to 50 lbs. to the inch. It is led down the shaft 80 fathoms deep in 4½-inch metal pipes, and hence in pipes of diminished diameter in the several directions of the workings, and finally into the "Banks" or working faces by India-rubber tubing of 1¼-inch diameter.

The use of air, underground, has many advantages. It is free from any kind of danger, and exceedingly manageable; there is nothing of an inconvenient or annoying character to be guarded against. It is clean, dry, pure, and cool.

Beyond all this, when the air has performed its mechanical work, it may be made available for sanatory purposes. When discharged from the cylinder of the coal-cutting machine, under a pressure of three

atmospheres, which at 100 strokes per minute, when expanded to its natural volume, gives about 300 cubic feet of air, this supply can be sent into each working face. This air, in expanding, takes heat from all surrounding bodies, thus lowering the temperature of the mine; and it, at the same time, increases the current, and dilutes the noxious agents which are found, as the products of respiration and of combustion, or such as are evolved from the coal itself. The advantages of these machines are most satisfactorily proved, and many coal proprietors have made arrangements for their introduction to their several works.* How will the invention be received by the mining population? is a question which many ask. Since the machine is to relieve the miner from his heaviest labour—to do, indeed, the drudgery of the pit—and thus tend to alleviate his condition, reserving his strength for less injurious trials, he cannot but feel that the aid afforded him is great, and we hope that he will receive it with all thankfulness.

In our anxiety to describe clearly the coal-cutting machines, so much space has been absorbed, that we feel compelled to defer to our next Number all notice of two or three machines—which have been devised, for working upon our hardest rocks,—used in driving levels and proposed for use in sinking shafts in our metalliferous mines.

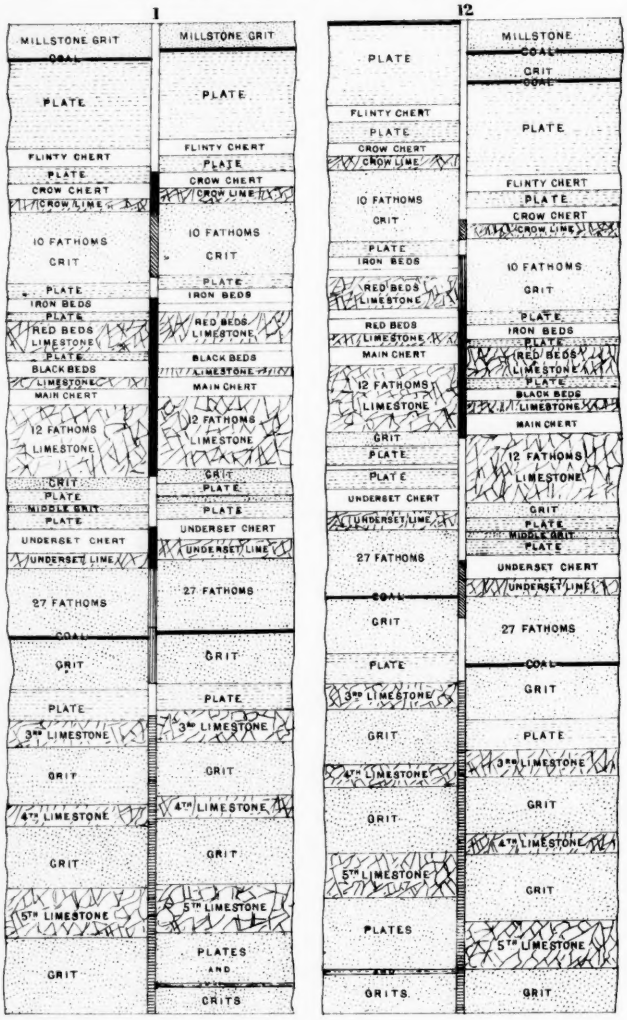
If the collier be exposed to injurious influences—and subject to violent casualties—the metalliferous miner is subjected to conditions so much more distressing, that, although we seldom hear of such dire calamities as those which follow from an explosion of fire-damp, it is too well known that the number who perish young, from the consequences of their labour, is far greater, relatively, than the deaths occurring amongst the coal-miners. Every mechanical aid, therefore, which proves a benefit in one case, becomes a yet greater blessing in the other. We expect before our second Number can appear, that the Report of Lord Kinnaird's Commission, "To inquire into the sanatory conditions of the metalliferous miner," will have been published, and, consequently, it will demand our attention in connection with the boring machinery—analogous to that employed in driving the tunnel through Mont Cenis—which promises to take the wearying task of "beating the borer" from the failing arm of flesh, and transfer it to the resistless arm of iron.

It is interesting to find, that some successful attempts have been made to introduce so much of science amongst our miners as promises to facilitate their labours, and relieve them from the liability to error, which is ever the attendant on ignorance.

The Miners' Association of Cornwall and Devonshire, and the Mining Schools of Bristol, Wigan, and Glasgow, are doing good work. At the same time as those local institutions, supported by limited subscriptions, are earnestly at work, the Royal School of Mines in London, supported by an annual vote from the House of Commons, is providing a numerous staff of young men furnished with all the resources of modern science, to undertake the direction of the ore-

* We believe that the new coal cutting-machine has been at work three months or more at the Ince Hall Colliery.—Ed.

VEINS WITH THROWS
OF ONE AND TWELVE FATHOMS.



mines, the engineering difficulties of which are rapidly augmenting with the increasing depth.

The uncertainty which attends the conditions of any of our mineral lodes or veins, is one of the causes which has led to the unfortunate spirit of gambling which marks too many Mining speculations. It may never be possible to pronounce with certainty, whether a mineral lode shall prove rich, in the metalliferous ores, in depth. But it is certainly within the limits of human knowledge to be able to pronounce on the high probabilities of any subterranean exploration being remunerative or otherwise.

The Philosopher who stands upon the surface of the Earth, and frames his hypothesis, as to the laws by which the metals have been deposited in the fissures of the rocks, is as likely to run wildly wrong, as the untaught miner, who, without a knowledge of one of the Physical Forces, persuades himself that he has an unfailing rule for determining the value of the hidden treasures. Neither the one nor the other will ever advance knowledge by his guesses. Teach the Miner to observe carefully, and to record his observations correctly—then call in the aid of the Philosopher, and his deductions from a sufficient number of well-observed facts will possess a high value. It is an important and a most favourable feature of the present time, that several practical miners are employed in endeavours to determine if any constant law can be discovered in relation to the accumulation of the Metalliferous ores in lodes.

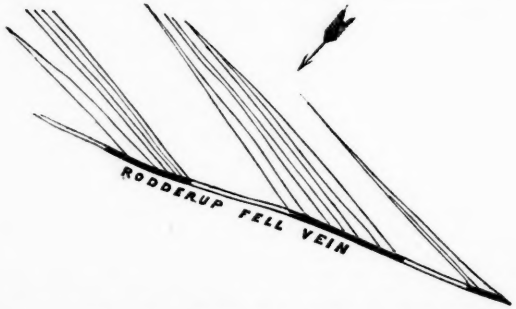
M. Moisenet, Ingénieur des Mines,—who has himself examined with great industry the Metal Mines of this country,—has endeavoured to refer the conditions of our mineral deposits to actions influenced by the direction of our great mountain ranges. In this country Mr. Lonsdale Bradley has published a valuable set of sections of the strata, in the lead-bearing rocks of Swaledale; and given careful explanations of the actual conditions observed in the veins.

Those sections instruct us on some points, which from their almost constant occurrence, assume the conditions of a law. These are that Limestones and Cherts are the beds which are productive of lead, and that the Grits and Plates are wholly unproductive. All mineral veins must be regarded as lines of dislocation; the strata seldom being precisely similar on both sides of the fissure or lode. Those disturbances are locally termed "throws." The sections published by Mr. L. Bradley appear to prove, amongst other facts, "That veins of simple throws are the most productive of lead-ore from having ore-bearing or ore-producing beds on each side of the veins, opposite or nearly so to each other;" "that veins of large throws are invariably unproductive, because the ore-bearing beds are thrown past each other, and that cross veins of large throws when productive of lead ore are usually so in the Limestones."* In the sections observed in 40 lodes, and given—carefully drawn to scale—in Mr. Bradley's book, these conditions are clearly shown. The accompanying lithographed examples of two kinds of "throw" will fully illustrate this position.

* 'An Inquiry into the Deposition of Lead Ore in the Mineral Veins of Swaledale, Yorkshire.' By Lonsdale Bradley, F.G.S. Edward Stanford, London, 1862.

A far more extensive inquiry has been made by Mr. Wallace of Alston Moor, with a view to the solution of this problem, and he is fully persuaded that, as far as this district is concerned, he has arrived at the true solution.* The balance of evidence is greatly in favour of the hypothesis put forth. It is not possible, within the limits of a summary notice, to explain satisfactorily the views of this writer. Suffice it to say, that Mr. Wallace regards the mineral lodes as channels through which, the waters accumulated on the surface, and percolating the rock, were discharged. These waters are supposed to derive from the adjacent rocks, or from some other source, the minerals which are subsequently deposited in those larger channels. The richness of any lode is determined by several conditions, all of which, however, may be regarded as disturbing causes. For example if, into a main channel of fissure, several lateral fissures flow, it is found that along the main fissure or lode, it is productive of metallic ores at these parts.

Several good examples of this are given in Mr. Wallace's beautifully executed map; one of these we copy. It is a portion of the great Rodderup Fell vein, and shows that the lode is unproductive except where the numerous small lateral veins, as shown in our drawing, have been channels in which fluids have been collected and conveyed to the larger fissure. The vein has proved remarkably productive of



lead in those parts. Mr. Wallace's book is a valuable contribution to the very limited literature which exists in the English language, on mines and mineral deposits. That attention has been awakened to this question, is further proved from the fact, that at the last meeting of the Miners' Association of Cornwall, two Cornish miners contributed papers on the subject.

Such are the matters of interest connected with British Mining, which have recently presented themselves.

As illustrating the value of our mines in relation to those of other countries, it is satisfactory to be able to examine two very recently

* 'The Laws which regulate the Deposition of Lead Ore in Veins: Illustrated by an Examination of the Geological Structure of the Mining Districts of Alston Moor.' By William Wallace. Edward Stanford, London.

published returns, which have been issued by the Governments of Spain and Prussia.

The number of productive mines, in Spain, in 1862, was 1,798, employing 32,789 miners. The results of their labours, and those of the smelter, were as follows:*—

	Minerals. Tons.		Metals. Tons.
Lead Ores	355,756		63,711
Copper „	228,098		2,857
Iron „	128,333	Cast	34,022
		Wrought	32,131
Zinc „	24,378		2,180
Quicksilver Ores	17,984		923
Silver „	2,960		$7\frac{8}{10}$
Tin „	1,860		$6\frac{9}{10}$
Coal „	326,162		—
Sulphur Ores	22,796		4,545
Manganese „	13,863		—

Of the above quantities, the Government mines of Linares produced of lead-ore, 3,521 tons; lead, 2,232 tons; those of Rio Tinto of copper-ore, 79,037 tons, or 1,170 of fine copper; and the important mercury mines of Almaden, 11,191 tons of ore of Cinnabar, yielding of quicksilver, 894 tons. Although Spain produces the largest quantity of lead-ores, its produce of lead falls below that of Great Britain, owing to the poorness of the minerals, their average produce falling below 18 per cent., while the produce of the lead-ores of England averages about 70 per cent.

The Prussian Government has published a valuable set of Mineral and Metallic statistics—being an account of the mineral production of the States for the ten years, 1852—61.† From this it appears that the total value of these products amounted in 1861, to 4,685,000*l.* sterling. The number of mines worked were 2,304, and of workmen employed 115,341. Notwithstanding the insignificance of these returns as compared with the mineral wealth of Britain, it is clear that the production of minerals in Prussia has increased more than six-fold during the past twenty-five years.

The latest returns furnished by the French Government of the production of "Metals other than Iron," show that in twelve departments there existed 23 mines in which were employed 3,072 workmen. The value of the argentiferous lead produced was 1,545,365 francs—and of other metals, 601,623 francs.

There are few sciences which move so slowly as Mineralogy—notwithstanding the Treatises by Dana,‡ by Brooke and Miller,§ and the

* 'Revista Minera.' Madrid, 1st Nov. 1863.

† 'Zusammenstellung der statistischen Ergebnisse des Bergwerks, Hütten- und Salinen-Betriebes in dem Preussischen Staate während der Zehn Jahre von 1852 bis 1861.' Bearbeitet von E. Althaus. 4to. Berlin: 1863.

‡ 'A System of Mineralogy; comprising the most recent Discoveries.' By James D. Dana, A.M.

§ 'An Elementary Introduction to Mineralogy.' By the late William Phillips. New edition, with extensive alterations and additions by H. J. Brooke, F.R.S., F.G.S., and W. H. Miller, M.A., F.R.S., F.G.S.

Glossary by Bristow,* which last will be found one of the most useful of books to the young student in this interesting field, the science of minerals makes no advance. This is referable to the cumbrous, unnatural, and confusing nomenclature which besets it. To call oxide of tin, *Cassiterite*, because it is found in a place which probably was at one time called The Cassiterides,—and to name Copper-glance, or disulphide of copper, *Redruthite*, on the erroneous supposition that the best specimens of this Mineral are found near Redruth, is neither more nor less than absurd. It is hoped that the system of exact nomenclature which has tended so much to advance Chemical science, will ere long be applied to Mineralogy.

There has recently been published in Paris a valuable Manual of Mineralogy,† to which we direct the attention of students. It was, the author informs us, his first intention to have translated the excellent work on this science by Brooke and Miller. He was, however, induced by some considerations, connected chiefly with the optical section of the science, to write a new book, of which the first volume only is published. To those students of Mineralogy who desire to enter earnestly on the study of Crystallography—and the optical characters of crystals—this Manual will be a valuable aid. The completeness with which the localities of the mineral described are given, renders this work an example to some of our English Mineralogists, who have not shown the requisite caution in determining these with exactness. Indeed, by trusting to some of these, M. Des Cloizeaux has occasionally been led astray.

Dr. Wedding, of Bonn, has directed attention to an ore of aluminium occurring at Baux, near Avignon; hence it has been named *Bauxite*. According to Meissionier, it penetrates the chalk as a vein-like mass for a length of nearly two miles. This ore has been mistaken for an iron ore, and employed as such. It consists essentially of alumina and peroxide of iron—which reciprocally replace each other—and water. It contains also small quantities of silicic acid, titanium, and vanadium; some varieties contain about 80 per cent. of alumina, and others almost as much oxide of iron. This ore is applied by MM. Morin and Co. of Nanterre, and Messrs. Bell of Newcastle, to the manufacture of aluminium.

The discovery of rock-salt at Middleton-on-Tees, by Messrs. Bolchow and Vaughan, is of great probable importance. A bed of rock-salt 99 feet in thickness has been pierced by boring at the depth of 1,206 feet from the surface. Mr. Marley's paper on this discovery, which was read at the Newcastle Meeting of the British Association, is about to be published in a revised form by the Institute of Mining Engineers—to this we shall again refer.

Professor N. S. Maskelyne and Dr. Viktor Von Lang, of the British Museum, have contributed some interesting notices of *Aërolites*, which are supposed to have fallen within recent years.‡ These

* 'A Glossary of Mineralogy.' By Henry William Bristow, F.G.S.
† 'Manuel de Minéralogie.' Par A. Des Cloizeaux, Tom. i. Paris: Dunod.
‡ 'Philosophical Magazine,' August, 1863.

notices were commenced in No. 165 of the 'Philosophical Magazine,' by a paper 'on Aërolites,' which included notices of a fall of stones at Butsura, in India, in May, 1861. Their more recent paper contains an account of two other meteorites. One of these stones fell at Khiragurh, 28 miles south-east of Bhurtpoor, on the 28th March, 1860. Another—of which a more detailed account is given—fell on the 16th August, 1843, at Manegaum, in the collectorate of Khandeish, in India.

Of the Manegaum stone, some fragments, amounting only to 2½ ounces, have been preserved in the collection of the Asiatic Society of Bengal, at Calcutta,* and a specimen is deposited in the British Museum. The evidence of the fall of this stone is given in the following words:—

"Two villagers described the fall as having been witnessed by them. There had been several claps of thunder with lightning some two hours previously, and the northern heavens were heavily charged with clouds; but no rain had fallen for eight days before, nor did any fall for four days after, the event. Their attention was arrested by 'several heavy claps of thunder and lightning,' and they ran out of a shed to look around, when they saw the aërolite fall in a slanting direction from north to south 'preceded by a flash of lightning.' It buried itself 5 inches in the ground, and appeared as a mass of about 15 inches long, and 5 inches diameter. It exhibited a black vitreous exterior, and was of a greyish yellow inside. At first, the observers stated it to have been (as is recorded of the Bokkeveldt aërolite) comparatively plastic, and at any rate to have become more hard and compact subsequently. There was only one stone seen, and that was smashed to pieces. Another witness mentioned that the stone was at first cool, but in a short time became rather warm." The evidence which is being accumulated by Shepard, Haidinger, and others, added to the chemical and physical examinations to which these aërolites have been subjected, by Rose, Maskelyne, and Lang, is advancing our knowledge of the peculiarities which belong to those remarkable bodies. The chemical constitution and the lithological characteristics of a peculiar class of stones, appear to prove their meteoric origin. It must, at the same time, be evident to all, that the utmost caution is necessary in examining all the evidence brought forward as descriptive of the phenomena accompanying the fall of stones through the atmosphere—and that, especially, which has led to the assumption that certain physical and chemical peculiarities are characteristic of, and unmistakably indicate, a true meteoric origin.

Dr. C. T. Jackson, of Boston, U.S., gives us some interesting particulars of a mass of Meteoric Iron from the Dakota Indian territory. It was found on the surface of the ground, 90 miles from any road or dwelling, and from its presenting a bright surface when cut, it was thought to be silver. A portion of about 10 lbs. weight was broken from the original mass, which weighed about 100 lbs. This

* 'Proceedings of the Asiatic Society of Bengal' for 1844 contains the first account of this aërolite.

was subjected to analysis, and its meteoric character supposed to be determined. The constituents of the Aërolite were—

Metallic Iron	91·735
„ Nickel	6·532
Tin	0·063
Phosphorus	0·010

Cobalt and chrome were also detected.*

We have already given the value of the Metallurgical products of British ores; there is little of novelty in the furnace operations to which they are subjected. Although numerous patents have been completed, and notices of many more given, for improvements in the processes of smelting the several metallic ores, there is scarcely anything of sufficient importance to require special notice. One Patent for "separating Silver and other Metals from Lead," founded on a principle discovered by M. Clement Roswag, Engineer, of Paris, promises to be successful.

In carrying out this invention, the first operation consists in fusing the lead containing silver and incorporating zinc therewith. For this purpose a suitable furnace is provided with a melting-pot or vessel, in which the lead and zinc are melted, the zinc being placed in suitable tubes or holders, and deposited, after the lead is melted, at the bottom of the vessel, so that as it melts it rises up through the molten lead by reason of its less specific gravity, and by means of agitators it is uniformly distributed in its passage through the fluid lead. When the whole of the zinc is melted and has risen to the surface of the molten lead, the zinc holders and the agitators are removed from the vessel, and the alloy of zinc and silver is skimmed off the surface, to be operated upon in the ordinary manner by oxidation. The molten lead, which now contains a small percentage of zinc, is next run off into the hollow of a reverberatory furnace, such as is generally used for annealing and refining lead, and the zincy lead is purified by keeping it in a state of fusion at a dull red heat, and subjecting it to the action of the vapours or gases arising from the burning or decomposition of pieces of green wood enclosed in suitable tubes or holders below the surface of the molten lead; the dross of the zinc (called seconds) is skimmed off during the process, and is added to the alloy of zinc and silver previously obtained. The lead thus refined is run into ingots for sale or use.

Under the name of *Wasium*, a new Metal has been recently announced by M. Bahr, as existing in the Orthite of Norway. M. Nicklès denies the reality of the discovery—according to him, the supposed new simple body is but impure Yttrium.

We expected to have examined Dr. Percy's second volume of Metallurgy, which will be devoted to Iron and Steel; although long since announced, it is not yet ready for publication. We may, however, safely predict that this work will be a valuable contribution to the Metallurgy of iron.

The late Exhibition furnished many striking illustrations of the importance of mechanical improvements to the worker in Metals.

* 'The American Journal of Science and Arts.' Conducted by Professor B. Silliman and others. No. 107, September, 1863.

This has been most strikingly shown in the application of mechanical engineering to several branches of iron manufacture.

There are few things which illustrate the giant power of machinery more entirely than the manufacture of armour-plates. A number of scientific men, and some of the Lords of the Admiralty, witnessed recently a great experiment with some new Rolling Mills belonging to John Brown of Sheffield. These rolls have a first foundation of no less than 60 tons of solid iron, resting on masonry carried far below the earth. The rollers themselves are 32 inches in diameter, and 8 feet wide, and are turned by an engine of 400-horse power. A powerful screw, applying its force through compound levers, allows the distance between the rollers to be adjusted to the fraction of an inch, so that the plate which on its first rolling, is forced through an interval of—for instance—12 inches apart is, on its next, wound through one of ten inches, next through one of 8 inches, and so on until the required thickness has been carefully and equally attained by compression through every part of the metal. When the enormous mass of iron to be rolled was first taken from the heating furnace, and brought to the rollers, it was found that they did not bite directly the mass came to them, and when they did, the engine was almost brought to a stand-still by the tremendous strain upon it; but at last the soft plate yielded, and the rollers wound it slowly in, squeezing out jets of melted iron, that shot about as the pile was compressed from 19 inches to 17 inches by the force of the rollers. From the time the mass had once passed through the mill, it was kept rolling backwards and forwards, the workmen sweeping from its face the scales of oxide that gathered fast upon it. Every time the plate was passed through, the rollers were squeezed closer and closer together, until at the end of a quarter of an hour from leaving the furnace, an almost melted mass, it was passed through the rolls for the last time, and came out a finished armour-plate, weighing 20 tons, 19 feet long, nearly 4 feet wide, and exactly 12 inches thick throughout from end to end.

Attention has been directed by Lieut-Colonel H. Clerk, R.A., to a matter of some engineering importance, "The Change of Form assumed by Wrought Iron and other Metals when Heated and then Cooled by partial Immersion in Water." The experiments recorded in a communication made by Colonel Clerk to the Royal Society originated in this way:—

"A short time ago, when about to shoe a wheel with a hoop tire, to which it was necessary to give a bevel of about $\frac{3}{8}$th of an inch, one of the workmen suggested that the bevel could be given by heating the tire red hot, and then immersing it one-half its depth in cold water. This was tried and found to answer perfectly, that portion of the tire which was *out of the water* being reduced in diameter." These experiments have an important bearing on many engineering problems; the general result appears to prove that metals heated to redness, and partially cooled, by having one portion only placed in cold water, contract about one inch above the water line, and that this is the same, whether the metal be immersed one-half or two thirds of its depth.

VIII. PHOTOGRAPHY.

By far the most important subject which has arisen in this branch during the last quarter, or, indeed, for many years past, is the alleged discovery of photographs taken half a century before the recognized birth of this art. An immense mass of evidence, direct and collateral, has been collected together in the most conscientious and energetic manner by Mr. Smith, Curator of the Patent Museum, and it certainly affords strong grounds for the presumption that no less than three, if not four, distinct classes of pictures, each by a different process, produced about the year 1790, are now in existence, there being the strongest circumstantial evidence that they are *bonâ fide* photographs. One is on a silver plate, pronounced by leading members of the Photographic Society to be an undoubted photograph from nature, the subject being Mr. Boulton's house, which was pulled down in 1791; the picture was found amongst papers in Mr. Boulton's library, which had not been disturbed during the present century. There are also two pictures—one of them undeniably a photograph—which were found by Miss Meteyard amongst papers supplied to her for the purpose of writing a life of Wedgwood, the great potter; and from documents of that date they are said to have been produced by the younger Wedgwood, reference being made to a lens, camera, and chemicals. There is also the hearsay evidence of an old retainer of the Boulton family, lately dead, of the silver picture of Mr. Boulton's house having been taken by placing a camera on the lawn; and there was a society called the 'Lunar Society,' the members of which were said to produce pictures by using a dark room, throwing the images on to a table, and fixing them by some chemical. The whole subject has recently been brought before the Photographic Society, and, on a careful analysis of the evidence, there is the very strongest presumption, short of absolute certainty, that this important discovery was made, and then suffered to die out. Only a few links in the chain are wanting to establish the actual proof, and from the intense excitement the subject has now occasioned, there is little doubt that it will be sifted to the bottom.

The measurement of the chemical action of light has lately received considerable attention. Dr. Phipson * has published a process which appears to promise very good results; it is based upon the fact, that a solution of sulphate of molybdic acid is reduced by the action of light to a lower state of oxidation; and by measuring this amount of reduction by chemical means, a correct estimate of the amount of actinism used up in the operation is obtained. The measurement is done with a standard solution of permanganate of potash; and Dr. Phipson states that his observations have disclosed the fact, that the amount of actinism during the day varies considerably, describing curves, which are not only irregular, but sometimes present sudden deflections of considerable extent. This phenomenon has been noticed before. During the last summer many correspondents of the 'Photographic

* 'Chemical News,' vol. viii. p. 135.

News' have stated that, on certain days during particular hours, there seemed to be an almost total absence of actinic force. In some instances five and six times the ordinary exposure were given with very imperfect results; and in other instances twenty times were tried with no effect. No particular atmospheric influence could be detected at work; and on subsequent days, apparently identical in light and clearness, photographic operations were conducted with their usual celerity. The cause of this great variation appears to have some connection with the dryness of the atmosphere, the days on which the absence of actinism was most marked having been intensely hot and free from humidity. It is much to be desired that a simple system of actinometry should come into general use. The processes of Draper, Niépce de St. Victor, Bunsen and Roscoe, Herschel, Phipson, and others, are very useful, but rather too tedious for general use. What we want is some method of reading off the amount of actinism as simply as we read off the amount of heat with the thermometer.

A most elaborate series of researches on the behaviour of chloride, bromide, and iodide of silver in the light, and on the theory of photography, has recently been published by M. H. Vogel.* The researches have extended over three years, and are of the most exhaustive character. We have only space to give some of the bare results which he has obtained, and must refer our readers for further particulars to the original memoir. The author considers that the action of light upon chloride and bromide of silver is first the production of a subchloride and subbromide, with liberation of chlorine and bromine, but that the iodide of silver undergoes no chemical change whatever. The action of acids and various saline solutions, especially nitrate of silver, has been studied very carefully, and some of the results are of considerable value. The effect of developing agents has been likewise examined, and the whole memoir constitutes one of the most important contributions to the science of photography ever published.

A valuable improvement has been inaugurated in the manufacture of lenses for photographic purposes. By the ordinary method of grinding and polishing, the surface is not left in a state of perfection anything approaching that required for astronomical glasses. For the usual photographic processes this surface is quite good enough, although, when carefully examined with a powerful glass, it will be seen covered with irregularities, the remains of the last stages of the grinding process. To attain greater perfection entirely different means have to be employed, and the costly nature of this operation is one reason why telescopic lenses are so valuable. For some purposes, however, in which it is absolutely necessary to get perfect delineation, as in the copying maps, &c., a lens ground in the ordinary way would be inapplicable, and perfection must not be hoped for unless the lens possesses a perfectly continuous spherical surface with the highest possible polish. Mr. Osborn, the photographer to the Melbourne Government, who is engaged in copying maps for the Melbourne Survey Office, has just ordered a lens from Mr. Dallmeyer, the cost of which is to be

* Poggendorf's 'Annalen,' 1863, p. 497.

250*l*. It will be a triple achromatic, and the glasses will probably require months for their completion, during the whole of which time the grinding and polishing machinery will have to be moving under the personal superintendence of one of the first practical opticians in England. The experiment is necessarily a costly one, and photographers are naturally anxious to see if the result compensates for the enormous additional expense. The Melbourne Government deserve the thanks of all photographers for the spirit of enterprise they have shown in the matter.

From time to time rock crystal lenses have been recommended on account of their superior transparency to the chemical rays of light. Mr. Grubb has put this theory to the test of experience, and finds that the difference is not so great as has been imagined; for instance, a compound lens of the ordinary make transmits 87 for every 100 rays which the rock crystal allows to pass. It is therefore only 13 per cent. worse, whilst in flatness of field and achromatism, the glass lens is much superior.

M. Gaudin suggests that lenses should be made from fused rock crystal. The manufacture of these is simply a question of expense, and they might possibly be achromatized by the employment of other suitably transparent minerals.

A new fixing agent, sulpho-cyanide of ammonium, is likely ere long to supersede hyposulphite of soda. The advantages claimed are, permanence of the print, and great facility in the washing operations; but, on the other hand, the expense is likely to be an objection. A little time ago, the new agent cost 4*s*. an ounce; there are rumours that it can now be procured in Paris for 1*s*. 1½*d*. per lb., although we have been quite unable to obtain any at this price, and Mr. Spence, the manufacturing chemist of Manchester, has just erected large apparatus, by means of which he hopes to supply the sulpho-cyanide at even a less price. We may therefore reasonably anticipate that sulphur toning, yellow whites, and fading positives, will soon have gone the way of the Dodo and Megatherium.

Celestial photography is making great strides on the other side of the Atlantic. Dr. Henry Draper has just completed a large reflecting telescope, 16 inches in aperture, and 13 feet focus, which he intends to devote to this branch of science. The mirror is of glass, covered at Sir John Herschel's suggestion, with a film of precipitated silver. It is sustained in a walnut tube, hooked with brass, and specially mounted to avoid tremor. When in use the instrument is allowed to be at rest, clockwork being used only to drive the sensitive plate. By this means, only 1 oz. instead of half a ton, is moved. A photographic laboratory is attached to the observatory, and the apparatus is arranged to take photographs of the moon as large as 3 feet in diameter, being on a scale of less than 50 miles to the inch. From the reputation which Dr. Draper has already earned as a photographer and physical philosopher, we are justified in expecting that celestial photography will advance rapidly in his hands.

IX. PHYSICS.

Light, Heat, and Electricity.

Light.—The cause of the scintillations of stars has long been a puzzle, not only to children, but to philosophers. Many explanations have been given, but none are quite satisfactory. Mr. A. Claudet* has thrown some new light upon this subject, by an instrument which he has devised, called the chromatoscope. He attributes the beautiful sparkling, with changing colours, exhibited by certain stars on a clear night, to the evolution in different degrees of swiftness of the various coloured rays they emit. These rays are supposed to divide during their long and rapid course through space, and we see them following each other in quick succession, but so rapidly that, although we see distinctly the various colours, we cannot judge of the separate lengths of their duration. Mr. Claudet's instrument consists of a reflecting telescope, part of which is caused to rotate eccentrically in such a manner, that instead of a point a *ring-like* image of the star is seen. The rapidity of rotation is adjusted so that each separate colour given by the star is drawn out into a large segment of the ring, and in that manner the light from the star can be analysed as in a spectroscope.

In observing the rays of sunlight through a powerful spectroscope many additional lines are visible when the sun is near the horizon. These are called telluric rays, as they have been shown to owe their existence to some components of the earth's atmosphere. Father Secchi, the Roman Astronomer, considers that aqueous vapour in the atmosphere is the principal cause of these telluric rays, and this opinion has been generally adopted by physicists: but M. Volpicelli† now describes experiments to prove that these rays are independent of the presence or absence of aqueous vapour in the atmosphere. In our opinion his experiments are scarcely conclusive; for it is quite reasonable to suppose that the passage of light through 100 miles of atmosphere might produce effects which could not be imitated in a laboratory experiment.

The determination of the refracting power of various transparent liquids and solids, a matter of considerable practical importance, is usually effected by reference to certain well-known lines in the solar spectrum. It would be much easier to have recourse to the bright spectral lines of coloured flames, which are obtainable with ease at any time, whereas the employment of Fraünhofer's lines is dependent on the weather. For accurate experiments it is necessary to know the length of the waves for the differently coloured rays, and this information has been supplied by Dr. J. Müller,‡ by means of one of Nobert's well-divided glass screens. His results show that the length of wave

* 'Phil. Mag.' No. 175.
† 'Cosmos,' vol. xxiii. p. 430.
‡ Poggendorf's 'Annalen,' vol, cxviii. p. 641.

of the red lithium line is 0·0006733 millimetres. The wave length of the yellow sodium line is 0·0005918 millim; * that of the green thallium line is 0·0005348 millim, whilst that of the blue strontium line is 0·0004631 millim.

Perhaps the most powerful spectroscope in the world has recently been constructed by Professor Cooke. It has nine bisulphide of carbon prisms, which are constructed of cast-iron, with parallel sides of glass, special precautions being taken to remedy the curvature of the glass plate from the hardening of the glue. The nine prisms are almost optically perfect, and the light is bent by them through nearly 360°. By its means Professor Cooke has established the following points:— 1. The lines of the solar spectrum are as innumerable as the stars; at least ten times as many being visible as are shown in Kirchhoff's Chart, with an infinitude of nebulous bands, just on the point of being resolved. No less than nine additional lines are seen enclosed within the fixed line D, one being nebulous and showing signs of resolvability under further increase of power. 2. It proves that the coincidences between the metallic lines of artificial spectra and the corresponding dark lines of the solar spectrum remain perfect under this increase of optical power. The two sodium lines can be spread out so as to allow of the thousandth part of the intermediate space being distinguished, and still their coincidence with the Fraünhofer lines is absolute. 3. Many of the bands of metallic spectra are broad coloured spaces crossed by bright lines; this is especially the case in the calcium, barium, and strontium spectra.

Some reliable experiments on the photometric value of the electric light have been published by Professor W. B. Rogers.† The battery was very powerful, consisting of 250 carbon elements, each having an active zinc surface of 85 square inches. They were grouped in fine battalions of 50 each, and the light was obtained in an apartment where a range of about 50 feet could be obtained for the photometric apparatus. Instead of an ordinary standard light, equivalent to 20 candles, a unit was substituted ten times as great, equal therefore to 200 candles. By a series of experiments with the naked electric light unaided by a reflector, it was found that its intensity was from 52 to 61 times as great as the standard light, making it equal in illuminating power from 10,000 to 12,000 standard sperm candles. With the rays concentrated by a parabolic reflector, its illuminating force had a value equal to several millions of candles all pouring forth their light at the same time. The only previous measurement of the illuminating power of the electric light which we can call to mind is one given by Bunsen. This was taken with a less powerful battery (48 cells), and the photometric equivalent was estimated at 572 candles; giving a proportion of 12 candles to the cell, whilst Professor Rogers' estimate gives the ratio of 40 candles to the cell.

* Fraünhofer's measurement for the dark line D of the solar spectrum gave it a wave length of 0·0005888.

† 'Silliman's Journal,' vol. xxxvi. p. 307.

An improved process for silvering glass for telescopic purposes has been published by M. Martin.* He uses four liquids:—The first being a 10 per cent. solution of nitrate of silver; the second, liquor ammoniæ sp. gr. ·970; the third, a 4 per cent. solution of caustic soda; and the fourth, a 12½ per cent. solution of white sugar, to which he adds a ½ per cent. of nitric acid, and after 20 minutes' ebullition adds 25 parts of alcohol, and water to make up the bulk to 250. The silvering liquid is made by mixing together twelve parts of solution 1; then eight parts of No. 2; next twenty parts of No. 3; then sixty parts of distilled water; and finally, in twenty-four hours' time, ten parts of No. 4. The object to be silvered is then to be immersed in, when it will be immediately covered with a film of reduced silver, which in ten or fifteen minutes' time will be sufficiently thick for use. After having been well washed with distilled water and dried, the surface may be polished with chamois leather and rouge.

During some researches on the compounds of mercury with the organic radicals, Dr. Frankland and Mr. B. Duppa discovered a substance which they call mercuric methide. This body is a transparent colourless liquid, of the specific gravity of 3·069, so heavy, in fact, that dense lead glass floats upon its surface. It has been suggested by Mr. Spiller that this would be an admirable liquid for fluid prisms. At present the only substance suited for this purpose is bisulphide of carbon, which is not half the density, besides being objectionable on account of its offensive odour, its great volatility, and easy ignition. Mercuric methide is superior to bisulphide of carbon in all these respects, and its preparation in quantity would not be attended with any particular difficulty.

A most ingenious application of some well-known facts connected with the reflection of light by prisms, has been brought forward by Mr. Henry Swan, at the meeting of the British Association. He takes two rectangular prisms of flint glass, placed with their widest sides in contact. The two copulæ of a stereoscopic picture are placed in contact with this combination, one being at the back and the other at the side. Upon now viewing this arrangement with the two eyes, the picture at the back is seen only by one eye, whilst the side picture is the only one seen by the other eye, the result being that the picture appears projected into the centre of the block of glass, possessing as much apparent solidity as if it were a model cut in ivory.

Heat.—The relation of radiant heat to aqueous vapour is being thoroughly investigated by Professor Tyndall.† He has found that pure dry air is almost perfectly transparent to heat-rays, but that, on a day of average humidity, the quantity of aqueous vapour diffused in London air produces upwards of sixty times the absorption of the air itself. This fact is of vast importance to meteorological science. Ten per cent. of the entire radiation of heat from the earth is absorbed by

* 'Comptes Rendus,' vol. lvi. p. 1044.
† 'Phil. Mag.' vol. xxvi. p. 30.

the aqueous vapour which exists within 10 feet of the earth's surface on a day of average humidity. Wet weather, saturating the atmosphere with vapour, acts as a warm blanket to the earth, whilst cold frosty weather, by drying the air, allows more heat to radiate from the earth, and produces a still greater degree of cold. The relation which these facts bear to many obscure phenomena of climate is fully discussed by Professor Tyndall in the paper already mentioned.

The destructive energy of hot water in steam-boiler explosions has been made the subject of an investigation by the Astronomer Royal.* As the result of many experiments, he concludes that the destructive energy of one cubic foot of water, at the temperature which produces a pressure of 60 lbs. to the square inch, is equal to that of 1 lb. of gunpowder.

A very sensitive thermometer has been described by Dr. Joule.† It consists of a glass tube, 2 feet long and 4 inches in diameter, divided longitudinally by a blackened pasteboard diaphragm, with spaces of about an inch at the top and bottom. In the top space a bit of magnetized sewing-needle, furnished with a glass index, is suspended by a single filament of silk. The arrangement is similar to that of a bratticed coal-pit shaft, and the slightest excess of temperature of one side over that of the other occasions a circulation of air which ascends on the heated side, and, after passing across the glass index, descends on the other side. As a proof of the extreme sensibility of the instrument, it is able to detect the heat radiated by the moon. A beam of moonlight was admitted through a slit in a shutter, and as the ray passed gradually across the instrument, the index was deflected several degrees, showing that the air in the instrument had been raised a few ten-thousandths of a degree in temperature by the moon's rays.

Many researches on the intensity of the electrical current developed by different thermo-electro pairs have been published by M. Edmond Becquerel; he finds that the best thermo-electric couple is composed of platinum and palladium, the two metals being unaltered by heat, and the intensity of the current increasing regularly with the temperature. This electric pyrometer was compared with graduated air-thermometers, and by this means many high temperatures have been able to be expressed in centigrade degrees. We give a few:—The boiling point of sulphur is 448°; the fusing point of silver is 916°; the fusing point of gold, 1,037°; the fusing point of palladium, between 1,360° and 1,380°; the fusing point of platinum, between 1,460° and 1,480°; the highest temperature of a fragment of magnesia, before the oxy-hydrogen blow-pipe, 1,600°; whilst the limit of temperature of the positive carbon of the voltaic arc is 2,000°.

A convenient gas-furnace for experimental purposes has long been wanted. Many contrivances have been made having for their object the production of a furnace-heat with gas, but they have invariably required an artificial blast of air, thus rendering it necessary for one person to be in attendance, and hard at work, during the whole of the

* British Association, Newcastle Meeting.

† 'Proceedings of the Literary and Philosophical Society of Manchester.'

operation. Mr. Gore* has described a new gas-furnace, which possesses many advantages over those hitherto used. It would be difficult to render its construction intelligible without drawings; but the value of it may be understood when we say that the smallest size will melt half-a-pound of copper or six ounces of cast-iron in less than a quarter of an hour, at a cost of about one halfpenny. The melted substances are perfectly accessible to be manipulated upon for a continuous and lengthened period of time, without contact with impurities or with the atmosphere, and without lowering their temperature sufficiently to cause them to solidify. Moreover, these advantages are secured by means of ordinary coal-gas and atmospheric air, without the use of a bellows or a lofty chimney, or of regenerators or valves requiring frequent attention.

Electricity.—The passage of an electrical discharge through various gases and between electrodes of various metals, gives rise to different luminous phenomena. When this light is examined in the spectroscope, it has been found that each elementary gas or metal possesses certain well-marked characteristic lines, and it has generally been assumed:—1. That each substance has a set of lines peculiar to itself. 2. That those lines are not produced or modified by any molecular agent except heat. 3. That the spectrum of one substance is in nowise modified by the presence of another; in such cases both spectra co-existing independently, and are merely superposed. 4. That electricity does not make matter luminous directly, but only by heating it, so that the electric spectrum differs in nothing from that produced by heat of sufficient intensity. Dr. Robinson has examined these questions in a long and laborious investigation, and the result has been presented to the Royal Society, in a Paper "On the Spectra of Electric Light." The opinion to which his results seem to point, is that the origin of the lines is to be referred to some yet undiscovered relation between matter in general and the transfer of electric action; the *places* of the lines being invariably the same, but their *brightness* being modified according to circumstances.

Since attention has been directed to the enormous variation in electric conducting power, caused by the admixture of even minute quantities of metallic or other impurities in copper, it has become a question of some interest to determine the electric conducting power of all the pure metals. Professor Matthiessen † has continued his researches on this subject, and has lately determined the electrical relations of pure thallium. At the freezing point of water this metal has a conducting power equal to 9·16 (pure silver being 100), and its conducting power decreases between the freezing and boiling point, 31·420 per cent., which is a larger percentage decrement than that obtained for many other pure metals, namely, 29·307 per cent.‡ The conducting power of pure iron was found to be, at 0° C = 16·81, with a percentage decrement for an increase of temperature to 100° C = 38·1. The conducting

* 'Chemical News,' vol. viii. p. 2.
† 'Philosophical Transactions,' 1863.
‡ 'Philosophical Transactions,' Part. I., 1862.

powers of the pure metals given in the following table, shows the places which the above metals take in the series.

	Conducting Power at 0°.
Silver	100·00
Copper	99·95
Gold	77·96
Zinc	29·02
Cadmium	23·72
Cobalt	17·22
Iron	16·81
Nickel	13·11
Tin	12·36
Thallium	9·16
Lead	8·32
Arsenic	4·76
Antimony	4·62
Bismuth	1·245.

It has long been a desideratum amongst electricians to obtain a battery having the constancy of Daniell's without the annoyance attending the use of a porous cell. Two such batteries have been described lately. One is the invention of M. Jacobini, and consists of a glass vessel, in which is placed a cylinder of copper pierced with holes; outside this is a larger cylinder of zinc. The copper cylinder is filled with powdered sulphate of copper, tightly pressed down, and the remainder of the space in the glass vessel is filled with sand, touching the zinc cylinder on both sides. Water is then poured in, so as to saturate both the sand and powdered sulphate of copper, and the arrangement is covered up. Several hours elapse before the electric current begins to develope itself actively. It then increases for a few days, and finally sinks again till its power becomes constant. Father Secchi has had a battery of this kind in use for three months, and reports that it is as efficient as when first constructed.

The other battery is the invention of M. Grenet, and is a modification of the sulphate-of-mercury pile of M. Marie-Davy. At the bottom of a glass jar a quantity of acid sulphate of mercury is placed. A stick of gas-carbon and a cylinder of zinc are supported upright in the jar by means of a cork, which closes the upper part of the vessel; water is then carefully poured in, and the whole is set aside, where it will not be shaken or moved. A wire connected with the carbon forms the positive pole, whilst the zinc forms the negative pole. The water becoming gradually charged with sulphate of mercury, attacks the zinc; the hydrogen which is evolved reduces the mercury on the carbon, and the metal as it accumulates falls down to the bottom of the vessel. If the apparatus is not shaken, there are formed two layers of liquid—the lower one consisting almost entirely of a solution of the mercury salt, whilst the upper layer contains the sulphate of zinc. It is owing to this separation that the porous vessel is able to be dispensed with. The battery is employed of two sizes—the larger one contains 500 grammes of water and 100 grammes of mercury salt; the smaller contains respectively 100 grammes and 30 grammes. They are said to keep in perfect order for six months at a time, without once requiring to be touched.

X. SANATORY SCIENCE.

If we were asked to state what it is that more especially characterizes the scientific Practitioner of Medicine of our own day, we should state it to be the strong desire whereby he is actuated to investigate the conditions which lead to the production of disease, the laws that regulate its propagation, and the means by which its exciting causes may be diminished or altogether destroyed. The modern physician does not waste his energies or burn the midnight lamp in anxious strivings after the philosopher's stone, in vain researches for some subtle elixir or fragrant balsam, with a few drops of which he might hope to charm away disease, to renew the life's blood, and impart to the frail and tottering form of age the vigour and elasticity of youth. Neither does he now rely in his treatment of disease on complicated formulæ, which like the once celebrated Mithridate of the ancients, consisted of some two score ingredients; nor on nauseous and disgusting remedies, which, like the oriental Bezoar stones, or the Album Græcum, were invested with a reputed efficacy proportioned to the repulsiveness of their origin. All this is now changed. A striving after simplicity is the order of the day. The sufficiency of the natural processes of recovery, when aided by a few appropriate remedies, is more widely recognized. The necessity of ensuring an abundant supply of fresh air, of practising social and personal cleanliness, of procuring a moderate yet sufficient quantity of food, and of guarding by precautionary measures against the special risks attendant on the pursuit of certain occupations, is now loudly proclaimed.

The importance of paying due attention to all such wise and simple sanatory regulations, is not only at the present time acceded to by the medical profession and the more intelligent of the general public, but has at length been fully recognized by the Legislature. The admirable reports which, in obedience to the Public Health Act for 1858, have now for a series of years been annually submitted to the Privy Council by their medical officer, Mr. Simon, have contributed in no small degree to the distribution of sound information on many of the causes that lead to the production of diseases, and on the means which ought to be taken to mitigate or prevent them. Of the many reports which have proceeded from his pen, there is none, we think, exceeding in general interest the one published in the autumn of the past year.* It embraces careful inquiries into the efficacy of the present system of public vaccination, and particulars as to the supply and distribution of vaccine lymph; into the diseases which may result from the pursuit of some industrial occupations; into the influences probably exerted by the distress in the cotton-manufacturing districts in the production and spread of typhus and other starvation diseases; on the effect produced on the human body by the consumption of the milk or flesh of diseased animals, and on the best steps for lessening the prevalence of disease amongst our domestic animals. As these subjects

* Fifth Report of the Medical Officer of the Privy Council. London, 1863.

all possess a considerable scientific and practical value, it may not be without interest to examine into some of the leading conclusions to which Mr. Simon has been led in the course of his inquiries.

The existence during the last few years of several wide-spread epidemics of small-pox, in different parts of the country, has caused much public attention to be directed to the working of the various statutes which the Legislature has enacted for the national protection against that disease. Doubts have even been thrown by some on the efficiency of the vaccine matter at present employed. It has been assumed that its protecting powers have been, through long-continued transmission from one individual to another, worn out or greatly impaired, and that a more frequent recourse to the original source from which it was obtained ought to have been resorted to. But on this matter Mr. Simon speaks both decidedly and assuringly. He requested Mr. Robert Ceely, of Aylesbury, "to whom more than to any man, since Jenner, the medical profession of this country is indebted for its knowledge of the natural history of vaccination," to inspect all the sources whence lymph is conveyed to the National Vaccine Establishment; and the result of that inspection has been to assure Mr. Ceely "of the perfectly satisfactory character of the lymph there in use."

Of the workings of the different enactments for ensuring a complete system of vaccination the report is anything but satisfactory—nay, the public defences against small-pox are in a great measure insufficient and delusive. The neglect of local authorities in enforcing vaccination in the workhouses and schools under their control; the imperfection of the arrangements for providing at the public expense thoroughly good vaccination, so that it should be everywhere and gratis within reach of those who may choose to avail themselves of it; and the omission in many cases to give the required notification of such arrangements, even when they may have been provided, have all operated in bringing Mr. Simon to this conclusion. But now that attention has been directed to these cases of neglect in the working of the existing machinery, it is to be hoped that means will be taken to ensure a thorough vaccination of the people, and if needful to compel it. We are slow indeed in this country to enact anything which may seem to impose an unnecessary restriction on personal liberty; but the personal liberty of the individual must always be subordinate to the general good. The welfare of the whole community is so closely connected with this question of compulsory vaccination, that we should not regret to see the day when the production of a vaccination certificate will be as essential to holding any office, to gaining employment, or to obtaining admittance to a school, as an attestation of correct principles and good moral character.

The diseases of animals employed as food by man possess an interest both in a sanatory and economic point of view. The influence which the flesh of diseased animals exercises upon those who may consume it has for some time attracted attention. Many strong representations on this subject have been made by Professor John Gamgee, Principal of the New Veterinary College, Edinburgh, and in

1862 he was requested by Mr. Simon to prepare a special report, which is included in the volume. The result of the very elaborate inquiries which Mr. Gamgee has conducted has been to show that disease has prevailed during the last few years, and still prevails very extensively, amongst horned cattle, sheep, and swine, and that the diseased animals are largely employed as human food. The diseases with which these animals are affected may conveniently be classed under three heads:—1st, Contagious Fevers; 2nd, Anthracic and Anthracoid Disorders; 3rd, Parasites. The chief forms of the contagious fevers are those which are more commonly known as the pleuro-pneumonia, or lung disease, of horned cattle, and the aphthous fever, murrain, or foot and mouth disease, which attacks not only horned cattle but also sheep and swine. Small-pox also sometimes attacks sheep, and not many months ago an outbreak of it excited much alarm in Wiltshire. What influence then will the consumption of the flesh of animals so diseased have upon those consuming it? Repulsive though it may be to our notions to eat the flesh of animals which have died of such disorders, and though we may be inclined on *à priori* grounds to suppose it might generate disease in those who eat it, yet more extended investigations must be made before we can state absolutely what the disorders are which it induces in the human frame.

The anthracic and anthracoid diseases are, it is said, frequently accompanied with peculiar changes, in some respects putrefactive, in the blood; erysipelatious and carbuncular affections also sometimes occur, and the body of the animal may develope in itself a specific morbid poison, which, by inoculation, can be communicated to other animals, and cases have been recorded in which disease and even death in man have followed the use of cooked meat derived from animals suffering from anthrax.

The parasitic diseases of the domestic animals are both numerous and important. The so-called "measles" of the pig is nothing more than the diffusion of a parasite, the cysticercus cellulosæ, through the muscular system of the animal; the "sturdy" of the sheep is due to the development of the cœnurus cerebralis in the brain; the "rot" of sheep to the production of flukes, a species of distoma, in the liver; a form of lung-disease is produced by the development in those organs of different kinds of strongylus;* and the muscular system may be infested by multitudes of a minute microscopic worm, the trichina spiralis. Now, there can be no question that meat affected with one or other of the above parasites may become the source of disease in man. Observations on this head have been so multiplied that this statement may be made in the most positive manner. That most troublesome and annoying of all the worms infesting the human bowel, *viz.* the tapeworm, has been shown by the researches of Von Siebold and Küchenmeister to be derived from eating the flesh of "measly" pork, the cysticercus cellulosæ of the pig becoming developed into the tænia solium of the human bowel: and by the ingestion of the cœnurus cerebralis, another form of tænia, the tænia cœnurus is produced. But perhaps the most curious of all these parasites is the

* A nematoid worm.

trichina spiralis which infests the muscular system. So long as it remains in the muscle, it lies quietly coiled up in a spiral form in a small cyst. But as the recent investigations of Virchow, Leuckart, Zenker, and Turner have shown, when the flesh of an animal containing these worms is swallowed, they become disengaged from their cysts, young worms develope in the interior of the females, and this takes place with such rapidity that in a few days the intestinal mucus becomes packed with multitudes of minute threadlike worms. Then from the intestines they migrate in swarms into the muscular system, and there enclose themselves in cysts possessing the same form as those with which their parents were enveloped. The flesh employed as human food which is most frequently infested by the trichina is that of the pig, and more than one case has now been recorded in which violent symptoms, and even death, have followed the use of the flesh of the trichinatous pigs,* and Professor Leuckart has found that trichina meat retains much of its injurious properties, even after some amount of pickling and smoking. We may learn, then, from these instances, how important it is that animals affected with such parasitic diseases should not only most scrupulously be avoided as articles of human food, but that their flesh should not even be given to other animals.

The great diminution which has taken place in the supply of cotton and the consequent stoppage of the factories of our numerous Lancashire towns, by throwing many thousands of persons out of employment, necessarily excited much anxiety not only as to how money was to be procured for their maintenance, but the best and most economical way in which this money was to be spent. The report that typhus fever was making its appearance in some of the towns also excited attention and alarm, and in obedience to the wishes of the Lords of the Privy Council, Mr. Simon requested Dr. Buchanan and Dr. E. Smith to visit the distressed districts and report upon the local precautions taken to prevent that destitution which breeds disease, and to obtain more exact information with regard to the minute economics of diet. The report of Dr. E. Smith is of a most complete and elaborate nature. He has in it endeavoured to answer two important questions. 1st. What is the minimum allowance of money to purchase sufficient food for the maintenance of health? 2nd. What is the best method of expending that allowance?

He has compiled a large collection of formulæ and dietaries, with the wholesale prices and nutritive values of the articles employed. His estimates are based on the real amount of nutriment which is required by these populations; *viz.* 30,100 grains of carbon, and 1,400 grains of nitrogen, weekly. He suggests that relief should be administered in three ways—in money, cooked food, and uncooked food. From the actual experience of the people, it would appear that single persons now spend weekly 2*s.* 4½*d.* each for food; but in the case of families, where there are young children, the rate of expenditure is

* As these pages are going through the press, we notice a paragraph in the daily public prints, in which it is stated that at Herrstadt, in Prussian Silesia, a large number of persons who had eaten at dinner trichinatous pork, were taken suddenly and seriously ill, and that of these sixteen died.

under 2*s*. This sum of 2*s*., at the present rates of prices for food, appears to be the dividing line between sufficiency and insufficiency, as by an expenditure below that sum, health cannot be maintained. There is also much interesting information on the comparative digestibility of certain foods, and on the influence which they exercise both on the secretions and excretions. This report of Dr. Edward Smith's we look upon as a valuable contribution to the study of dietetics, and one which ought to be carefully perused by all who take an interest in providing economically a due quantity and variety of nutritious food for the poor and destitute.

The effect produced by the pursuit of certain occupations, on the health of the employed, has for some years past excited much attention.

The prevalence of phthisis amongst file-makers, the tendency to bronchitic disorders exhibited by coal-miners, the paralytic affections and attacks of colic so frequent amongst workers in lead and its compounds, the diseases of the nervous system which attack looking-glass silverers, watch gilders, and others exposed to mercurial emanations, have long been subjects of discussion, and many ingenious plans, mechanical and otherwise, have been devised for warding off the pernicious effects resulting from the pursuit of such occupations. The increase which has of late years taken place in the industrial applications of phosphorus, and of the compound of arsenic called emerald green, or Scheele's green, and the cases in which injurious, nay fatal, effects have been produced on those employed in their manufacture and use, induced Mr. Simon to request Dr. Bristowe and Dr. Guy to make inquiries and report thereon. From the careful examination which Dr. Bristowe has conducted into the methods employed in lucifer match-making—the chief industrial application of phosphorus,—he concludes that the disease of the jaw-bone, to which match-makers are especially liable, might be altogether avoided if amorphous instead of common phosphorus were employed, and that this form of match would possess the additional advantage of not being spontaneously combustible, and therefore not so liable to cause fires. There are, indeed, certain difficulties in the way of carrying out the application of the amorphous phosphorus. But it is the opinion of Mr. Albright, one of the largest manufacturers of phosphorus, "that if the use of the common form were prohibited, the end would be attained completely in six months, to the satisfaction of the manufacturers and the public advantage."

The recent extensive employment of emerald green in the manufacture of wall papers, coloured ornaments of confectionery, artificial leaves and flowers, green tarlatans for dresses, children's toys, &c., has afforded Dr. Guy abundant material for the preparation of his interesting report. He makes many suggestions as to methods which might be adopted to prevent or diminish the risk of poisoning by this pigment, and we recommend all those who may be connected with the different branches of industry in which this brilliant green is employed, to attend carefully to the conclusions to which he has arrived.

At those two great scientific Congresses, the British Association for

the Advancement of Science, and the Social Science Association, which now assemble every autumn in one or other of our large towns, various questions affecting public health were at their last meetings brought before their appropriate sections. To some of the most important of these we will now refer. As was not unnatural, the meeting of the British Association last autumn in Newcastle, the centre of one of our most important coal-producing districts, called forth some interesting papers by Drs. Wilson, White, and B. W. Richardson, on the habits and diseases of the miners, and on means which might be employed for diminishing the evil effects of breathing noxious vapours and gases. An excellent paper by Dr. G. Robinson, on organic effluvia, was also communicated, in which the author showed that those abnormal constituents of the atmosphere which are recognized under that term, may be resolved into four principal groups, *viz.*:—1st. Gases and vapours formed during the decomposition of organic matter. 2nd. Odoriferous particles *sui generis*. 3rd. Volatile organic matters not endowed with vitality. 4th. Living germs. On those last-named constituents of the atmosphere many valuable observations were made by Mr. James Samuelson, whose suggestion that the atmosphere of hospitals should be tested microscopically for living germs, appears to us to be of much importance.

The great Sepoy mutiny, &c., by necessitating a much larger number of European troops to be retained in India for defensive purposes than was formerly required, has compelled the attention of the authorities to the need of greater care in promoting and preserving the health of the soldiers stationed there, both in camp and barracks. Papers on this subject were read before the British Association by Drs. Bird, Stewart, Clark, and Camps, and at the Social Science Association by Miss Nightingale and the Rev. Dawson Burns. From the report of the Royal Commission on the sanatory state of the army in India, it would appear that the death rate amongst the British troops serving in India amounts to no less than 69 per 1,000 per annum. Now taking the strength of the British army in India at 73,000, it follows that such an army would lose somewhat over 5,000 men annually, equal to an entire brigade. And as in unhealthy seasons the death rate rises to double the above amount, we may well ask with Miss Nightingale, "Where are the 10,000 recruits to be found to fill up the gap of a single unhealthy year?" and say with her, "that on the better preservation of the health of our troops—hinges the very important social question, *viz.*—How the British race is to hold possession of India, and to bestow upon its vast population the benefit of her own civilization?" This great mortality is due to two distinct sets of causes, for one of which the authorities are responsible; the other is to be ascribed to the personal habits of the men themselves. The building of barracks in bad situations, the crowding together of a large number of men, the insufficient supply of fresh water, the imperfect ventilation, and the deficient drainage are all causes of disease which are under the control of the Government, and for which it ought to be made responsible.

The excessive use of animal food and ardent spirits are those vices

amongst the personal habits of the soldier which call most loudly for correction and reform, and we cannot but think that if proper steps be taken, the mortality arising from them may be largely diminished. Experience has shown that the proper carrying out of sanatory principles in other parts of the globe in which British troops are quartered, has succeeded in effecting great improvements in the health of the men, and we see no reason why the same good result should not follow the application of the same principles in our Indian empire.

We cannot close this brief *résumé* of some of the most important recent contributions to Sanatory Science, without directing attention to the suggestive address on many matters connected with public health, delivered at the Edinburgh meeting of the Social Science Association, to the department over which he presided, by Professor Christison.

In this address Dr. Christison inquires into the mode in which the principal diseases or groups of diseases are influenced by the agents which affect public health. One of the most remarkable facts which he elucidates is the total disappearance of ague which has of late years taken place in Scotland, a country in which at one time it was very common. This disappearance does not indeed seem to be coincident with the drainage and agricultural improvements which have been carried on so energetically there for many years past; for the decline in the disease took place before such improvements were carried out. The co-existence of typhus fever with deficient ventilation and cleanliness and want of work is forcibly pointed out, but the decline which has of late years taken place in Edinburgh in the number and fatality of the visitations of this disease is ascribed by the Professor to changes in the type or constitution of epidemic diseases, rather than to any satisfactory improvement in the cleaning of the lanes and houses of the working classes. In the case of the typhoid or enteric fever, Dr. Christison thinks that something more is to be looked for in endeavouring to decide upon its mode of origin than ill-drained streets, defective water-closets, and foul air. All these circumstances certainly favour its invasion, but its true cause lies in something more specific, and whilst better drainage and more perfect ventilation ought to be encouraged, yet they alone are not sufficient to extirpate enteric fever. These statements are in opposition to much that recent writers, both medical and non-medical, have been for many years back strongly inculcating, and, as was naturally to be expected, have not been allowed to pass unchallenged. But we cannot help thinking that as the deliberately expressed opinions of a physician, who has possessed opportunities of studying fever second to no man, they are deserving of much careful consideration. From a statistical comparison of the mortality of the large towns of Scotland with the agricultural counties, the greater frequency of the diseases dependent on a depraved state of the constitution in the former than the latter is, as might naturally be expected, clearly proved. The address concludes by showing that the Western Islands of Scotland, in spite of their mist-laden atmosphere and exposed position, enjoy an almost complete immunity from pulmonary consumption.

XI. ZOOLOGY AND PHYSIOLOGY.

Professor Owen has made a Report upon the departments of Natural History in the British Museum for the year 1862, which speaks favourably of the general condition of the collection as to preservation, though, as far as the stored animals in the vaults—many thousands in number—are concerned, each successive year of such storage increases the difficulty of keeping the specimens in a good state. The skins of Mammalia and Birds are in good condition, and available for scientific examination, though exhibiting some signs of the effects of damp. The Insects and Crustacea are also easily available, and in good condition; but the Mollusca in spirits are so crowded, that access to the specimens not in the front row is difficult and hazardous, and their utility greatly abridged. The exhibited specimens in the various galleries are described as showing only the degree of detriment which is inevitable from exposure, with the utmost amount of care; but these are in general so crowded as to impair their utility. The additions to the Zoological department in the year 1862, were 13,129 in number, including several great rarities and valuable specimens, such as *Troglodytes vellerosus*, a new anthropoid ape, discovered by Captain Burton in the Cameroon mountains of West Tropical Africa; a new tortoise (*Cyclemys Mouhotii*), from the Lao Mountains in Cochin China; three or four new species of crocodiles; 1,911 fishes have also been added, many of them new species, and of them 128 have been placed in the British Collection.

M. Thury, Professor in the Academy of Geneva, has made a discovery, which, if it be corroborated, will be one of the utmost value in the farm and homestead. He has arrived at a formula for obtaining cattle of either sex *at will*. The duration, character, and signs connected with the period of heat in the cow upon which it is proposed to experiment must be first ascertained. These being known, in order to ensure a cow-calf congress must be effected on the first appearance of the access of this period; while a bull-calf may be as certainly ensured, by making use of the termination of this period. It is necessary to exclude from the experiment those animals in which the signs of heat are vague and uncertain, as is observed in fat cattle, and confined individuals; but healthy cows, and those living in the open air, must be used for the purpose. The experiments made upon cattle at Montet, appear to have been decisive, if we may judge from the following results:—"In the first place," says the breeder, "in twenty-two successive cases I have sought to obtain heifers; my cows were of the Schwitz race, and my bull pure Durham blood. I obtained the result sought for in *every case*. Having later purchased a Durham cow, I sought to obtain a pure Durham bull-calf, and succeeded, and have since obtained six other bulls, crossed between Durham and Schwitz. Altogether, I have made twenty-nine experiments, and every one has given the result sought." The importance of such a law will be evident,—and especially will such results be valuable in

countries where it is desirable to obtain oxen for working purposes; as in others, cows are the most valued animals. Moreover, the same remarks will apply to *sheep*.

A series of experiments is about to be conducted on the Imperial farm at Vincennes, in order to test the value and truth of the discovery.

While on the subject of cattle, it may be well to refer to a practice adopted by M. Charlier, for the suppression of horns, an operation which may sometimes be of great advantage. In the early months of life, when the rudiment of the horn begins to appear, it may be done without danger or expense, the owner himself operating with facility. The instrument used is a kind of trephine, a small cylinder of good steel, with a sharp cutting edge at one end and a point at the other. This instrument is placed around the young horn, bearing sufficiently on it to cut through the skin and subjacent tissue at the base of the horn, and then everting the soft horn, which offers no resistance. The wound heals in a few days afterwards without suppuration, and generally without any febrile symptoms.

In the beautiful and elaborate Memoir published by the Smithsonian Institution (Smithsonian Contributions to Knowledge, xiii. 169), entitled 'Researches upon the Anatomy and Physiology of Respiration in the Chelonia,' by Drs. Weir Mitchell, and G. R. Moorehouse, some curious errors of previous writers are pointed out with regard to the respiratory movements in Turtles. All writers upon this subject, including Malpighi, Cuvier, Johannes Müller, Milne Edwards, Agassiz, &c., appear to have described the act of breathing to be performed by them thus:—by the depression of the hyoid apparatus and tongue air is drawn into the mouth through the nostrils, which are then closed; and by raising the hyoid, air is driven from the mouth through the glottis and trachea into the lungs, when inspiration is completed. Expiration being effected by the contraction of the abdominal muscles, and the consequent compression of the lungs. Instead of this, the authors of this Memoir have proved that the hyoid apparatus has nothing whatever to do with ordinary breathing, but that *inspiration* is performed by the abdominal muscles, which naturally form a deep concavity, but contracting become flat, draw down the viscera, enlarge the cavity of the trunk, which enlargement is followed by a rush of air through the trachea into the lungs, when inspiration is completed; while expiration is produced by the action of a peculiar muscle, now first completely described, like a broad digastric, which arises from the fore and hind part of the shield, and unites by a broad tendon across the middle of the abdominal cavity, between which muscle in front and the shield behind, are included the viscera—and by contraction of which *expiration* is effected. It is remarkable that this correct view has since been found by the authors to be set forth in a dissertation on the subject written at Göttingen, in 1795, by Robert Townson, LL.D., and they were surprised, on learning the singularly correct views there propounded, to find that they had ever since been either unappreciated or condemned.

Signor Trinchese has been engaged in the investigation of the

nervous system of the Gasteropodous Mollusca, taking as types the Helix pomatia, Arion rufus, and Lymnæa stagnalis. He finds that in all the nervous centres of these animals there are,—round or pyriform cells of variable dimensions, enveloped in a thick sheath of connective tissue; small cells of irregularly triangular form, round which no envelope is perceived; and free nuclei, like those met with in the grey matter of the cerebro-spinal axis in Vertebrates. The cells usually present four prolongations, passing to each of the cells surrounding them, whilst other processes pass between the latter to other cells at a greater or less distance. These cells are usually found in the peripherical portions of the ganglia, the interior being occupied with fibres and conjunctive tissue. The optic ganglia consist of free nuclei and nervous fibres proceeding from the anterior part of the cerebroid ganglia, two in number. On the anterior portion of them in Helix and Arion, there are four small accessory cerebroid ganglia; and on the course of the nerves connecting the cerebroid masses with the pedal or abdominal ganglion, there is a small ganglion, composed of cells united in groups, like the compartments of an orange. The peripheral nerves are formed of very delicate tubes, having on their walls nuclei similar to those which are observed in the higher animals in the Embryonal state. Their mode of termination in the muscles is remarkable. The nervous element on arriving at the muscular fibre, loses its proper wall, and the axis-cylinder alone penetrates the muscle, dividing into two very slender filaments. These take opposite directions, each traversing one-half of the muscular fibre, on arriving at the extremity of which they terminate in very fine points.

Although we have long been acquainted with the young state of the true crabs, and hermits, under the form known as Zoëa, especially distinguished by the want of the ten feet to which the adult animals are indebted for their name of Decapoda, it is only recently that Fritz Müller has described the Zoëa forms of the Porcellanæ as approaching most closely to those of the crabs. He has now added the interesting fact that in certain Prawns and Stomapoda (as probably Squilla mantis) similar conditions occur. The metamorphosis of the former commences sometimes (as in the Cirripeds) with monoculoid forms, and passes through very peculiar Zoëoid and Mysis-like states, sometimes with Zoëa forms which in structure and mode of movement resemble those of Hermit Crabs, whilst in others we can hardly say that there is any metamorphosis. Dr. Müller has, however, described and figured a little animal which he considers the Zoëa of a Stomapod, of glassy transparency, in which the segments exist in almost the same number as in the mature Stomapods, the sixth and seventh abdominal segments only being not yet distinct from each other. As in the Zoëæ of the Crabs and Porcellanæ, the appendages of the sixth hinder thoracic segments, and the lateral laminæ of the caudal fin were also as yet entirely deficient. They possess only a median eye.

So little is known of the habits and modes of life of marine animals, that we cannot but feel much interested and deeply indebted for carefully observed facts in this department. Such are those of the curious

relations existing between the Crab, Pagurus Prideauxii, and the Zoophyte, Adamsia palliata. These two incongruous animals are, it is well known, constantly found associated together, and although we have found them difficult to keep alive in an aquarium, Lieut.-Col. Stuart Wortley has been more successful, and has observed the crab, after eating two pieces of meat given to it, seize a third with its large claw, and thrust it into the expectant mouth of the Adamsia. This has been frequently repeated. On leaving its shell, for the purpose of establishing itself in a new one, the Pagurus returned to the old shell, and dislodged the Adamsia with its pointed claws, during which rough process no acontia were thrown out, as would be done on the slightest irritation from any other source; and when entirely separated, the crab holds it firmly with its base against the new shell until it has affixed itself. It remained on one occasion for an hour in this position, when, finding Adamsia did not affix itself readily, it returned to its old shell upon which Adamsia firmly attached itself as before. So attached does the crab appear to be to its helpless companion, and so loath to quit its hold upon it, that Col. Wortley concludes, as we were inclined to do from facts observed in dredging when they were abundant, that Adamsia palliata is almost, if not quite, a necessity of existence to Pagurus Prideauxii. The converse, however, cannot be said, for we have kept a specimen of Adamsia alive for twelve months unattached to any shell, the Pagurus having died on the day succeeding its capture.

Another remark on the habits of Crustaceans has been furnished by Mr. Moore, Curator of the Liverpool Museum, in reference to the King Crab (Polyphemus) of which several living specimens have been sent over by Professor Agassiz. The long spine-like tail of this species has excited much question as to its use. If they are turned over on their backs, they bend down the tail until they can reach some *point d'appui*, and then use it to elevate the body and gain their normal position. The function assigned to it by some, *viz.* of placing it under the body and leaping from place to place, has never been observed.

Rudolf Leuckart has made some interesting observations upon the development of the *Acanthocephali*, the only group of *Entozoa* whose development had hitherto eluded the investigations of naturalists. Scattering the ova of six or eight *Echinorhynchi* of the species *E. proteus* in a bottle containing *Gammari*, he found in a few days a great number of these ova in the intestines of the Gammari. The embryos quitting their envelopes passed into the abdominal cavity of the Crustaceans. After three or four weeks the embryo underwent a singular metamorphosis, which converted its nucleus into a true Echinorhynchus, like an Echinorderm in its Pluteus. This rapidly increases in size, and finally fills the body of the embryo, which becomes transformed into the envelopes external to the muscular tube of the worm, and distinguished by a proper vascular system. When the spinous armature of the head is formed, it draws back into the posterior part of its body like a *Cysticercus* in its vesicle. Leuckart has counted fifty or sixty parasites in a single Gammarus.

Considerable attention has been devoted to the characters of the

Amœbina, by two gentlemen who, though they do not agree in all their results, will no doubt by a friendly rivalry the better tend to elucidate the truth. These are Dr. Wallich and Mr. H. J. Carter. Dr. Wallich insists upon the absolute necessity of long-continued and daily observation whenever it is desired to elucidate the characters and vital phenomena which appertain to the lowest forms of organic existence; and entertains the view that probably many, if not all, the previously described species of Amœba are referable to, and constitute mere phases of *Amœba villosa*, the most highly developed type. Mr. Carter, however, regards certain characters of primary importance, and typical of *A. princeps* (Ehr) as reconstituted by him, while Dr. Wallich urges these characters as distinctive of *Amœba villosa* as already described by him. The characters which Mr. Carter claims for his *A. princeps* are its large size and the number of granules it contains; its limacious though protean form, its lobed and obtuse pseudo-podia proceeding from a posterior end, normally capped with a tuft of villous prolongations; while the nucleolus is so much extended over the inner surface of the nuclear cell, that it passes beyond the equatorial line of the latter, preventing any halo round the nucleus, as in other Amœbæ; but the border of this nucleus is wavy when it has attained the 450th of an inch in length. The anomaly in the configuration of the nucleus, however, Mr. Carter afterwards resigns as a distinctive character. With regard to the apparent circulation in these low organisms, Dr. Wallich believes that it is not a vital act, but a secondary and mere mechanical effect consequent on the inherent vital contractility of the sarcode. The particles simply flow along with the advancing rush of protoplasm, and there is no return stream. The numerous and lengthy papers of Dr. Wallich and Mr. Carter, in the 'Annals of Natural History,' on the subject of these organisms tend to the combination not only of species, but of genera which have always hitherto been regarded as perfectly distinct.

The difficulty of distinguishing the lowest animal forms from vegetable bodies has received a good illustration from some observations of Mr. H. J. Carter, well known for his papers upon Rhizopods, on *Difflugia*. He has shown in this species (*D. pyriformis*) that chlorophyll cells exist as part of its organization, and that starch cells, until recently believed to be a peculiarly vegetable product, form part of its products. Moreover, he has observed conjugation similar to that of the contents of the cells of *Spirogyra*, and that apparently after this conjugation, when the body of the *Difflugia* is densely charged with chlorophyll cells and starch granules, the nucleus becomes charged with spherular, refractive, homogeneous bodies, which appear to be developed in the protoplasm that lines (?) the nucleus. These spherules pass from the nucleus into the body of the animal, and there, becoming granuliferous, so increase by duplicative division, as to form the chief bulk of the whole mass, while the chlorophyll cells have *entirely* disappeared, and the starch granules have become more or less diminished in number. Colourless specimens of Difflugia having been placed in water, after four days the bottom of the vessel became covered with granuliferous cells of the same size and appearance

as those peculiar to the colourless specimens, but with the difference that they were all provided with a cilium (perhaps two); most were fixed and retained their globular form; others swam about by means of their cilium; many of the fixed globular forms altered their shape by becoming polymorphic; and some lost their cilium and became altogether reptant and amœbous. There can be little doubt that these Amœbæ are the young brood of *Difflugia pyriformis*. Thus the cycle of generative development in this Rhizopod by "granulation of the nucleus" is so far completed. It is probably the same as in *Amœba princeps*. The development of the young *Amœba* into adult testaceous *Difflugiæ* has not yet, however, been observed.

We should hardly be prepared for psychical development in these minute masses of sarcode, nevertheless Mr. Carter's observations of Æthalium and Actinophrys render it probable that certain manifestations of instinct are occasionally evinced by them, of the same kind as those in the higher animals. On one occasion, for example, Mr. Carter observed an Actinophrys station itself close to a ripe spore-cell of *Pythium*, which was situated upon a filament of Spirogyra, and as the young ciliated germs issued forth, one after another, from the dehiscent spore-cell, the Actinophrys remained by it, and caught every one of them even to the last, when it retired to another part of the field, as if instinctively conscious that there was nothing more to be got at the old place. As, however, these lowest forms of life appear to have but one object, and that the attainment of food, we cannot be so much surprised if they are provided with sufficient discrimination to be aware when they are receiving it, and when the supply has ceased. Indeed their whole instinctive development is concentrated upon that important end.

REVIEWS.

THE BIRDS OF INDIA.*

The want of text-books on the Natural History of our colonial and foreign possessions, has been long and severely felt by the many residents in them who are desirous of employing their hours of leisure or recreation, in the pursuit of this most attractive study. As regards Botany, the energy of the Director of the Royal Botanic Gardens at Kew has already accomplished much towards the attainment of this desirable object. Some years since, Sir William Hooker's urgent representations to the Colonial Office succeeded in inducing that department to take into consideration a scheme which he propounded, for issuing a complete series of Manuals of the Botany of the different Colonies, and although the small sums necessary to effect this object were, with one exception, grudged to him by the Imperial Exchequer, the Colonies themselves have in many instances taken up the matter, and there is little doubt that Sir William Hooker's scheme will eventually be carried out in its integrity.

Our zoologists have not as yet followed the good example thus set before them. Their field of operations is much more extensive, they are less united as a body, and they have certainly no single leader amongst them, who occupies a corresponding situation to that filled by Sir William Hooker with regard to the sister science. So far as concerns the zoology of our foreign and colonial possessions, therefore, we must for the present look to what the unassisted energies of private individuals can accomplish. And we must be thankful when even such indirect sanction and assistance as the Government of India has bestowed on Dr. Jerdon's present undertaking can be obtained.

Dr. T. C. Jerdon's name is well known in connection with many contributions to the Natural History of India, which he has made during a long service, in different parts of that country, as a medical officer of the Indian army. In 1839, Dr. Jerdon commenced the publication in the 'Madras Journal of Literature and Science' of a catalogue of the birds of Southern India. This with its supplements was completed in 1844, and still remains our best authority on the ornithology of the districts of which it treats. In 1844, Dr. Jerdon

* 'The Birds of India: being a Natural History of all the Birds known to inhabit Continental India; with Descriptions of the Species, Genera, Families, Tribes and Orders, and a Brief Notice of such Families as are not found in India; making it a Manual of Ornithology specially adapted for India.' By T. C. Jerdon, Surgeon-Major, &c. Calcutta, 1862. Vols. I. and II. pt. 1.

also published a series of illustrations of Indian birds,* in a quarto volume of fifty plates, in which many rare species were figured for the first time. Besides this, he has contributed many papers relating to Indian zoology to different scientific journals, and has been a most indefatigable explorer and collector in nearly every province of India. It cannot be doubted, therefore, that Dr. Jerdon's qualifications to carry out the plan he now proposes,—that is, to issue a series of Manuals of the Natural History of the Vertebrated Animals of India,—are very considerable. And looking to the way in which he has commenced to execute his plan, in the case of the two volumes now before us, which form the first part of his 'Manual of Indian Ornithology,' we have every reason to be satisfied that it has fallen to his lot to undertake it. Nor can it be doubted that such a series of manuals is a great desideratum. At present, as Dr. Jerdon observes, to "obtain acquaintance with what is already known respecting the Fauna of India," it is necessary to "search through the voluminous transactions of learned societies and scientific journals," which are of course quite inaccessible to residents in an Indian up-country station, and hardly to be referred to even in Madras or Calcutta. Dr. Jerdon's aim, therefore, is to supply in a few portable volumes the information requisite for a student of any branch of the natural history of the vertebrata of India to ascertain what is already known of his favourite science and to what points especially he should direct his inquiries. The two volumes already published by Dr. Jerdon take us through the greater part of the class of birds; a third volume, shortly to be issued, will complete this part of the subject. The author will then turn his attention to the Mammals, Reptiles, and Fishes, and treat of each of these classes of animals in a similar manner.

Dr. Jerdon introduces himself to his readers in the first volume of his present work with a well-written chapter of general remarks, which will repay perusal. After giving an outline of the structure of birds, external and internal, and some remarks on their migration, he proceeds, before entering upon the subject of classification, to devote a few words to the much-vexed question of the differences between species and variety. A *species*, Dr. Jerdon defines as consisting of a "number of individuals closely resembling one another in size, structure, and colour, and propagating a like race;" a *variety*, as "consisting of one or more individuals resembling certain other individuals sufficiently to be considered identical in species, and yet differing in certain external points of colour, size, or form." As regards the mode in which this difficult subject, as encountered in the case of the birds of India, has been dealt with, the following remarks of our author may prove of interest:—

"Some naturalists believe that permanent varieties are common in the animal kingdom, and Kaup calls them *sub-species*. Such persons consider that their differences from other individuals, of what they would term the typical form, do not entitle them to the full rank of a species. Others, again, deny that permanent varieties exist, and state their conviction that

* 'Illustrations of Indian Ornithology.' By T. C. Jerdon. Madras, 1844. 1 vol. 4to.

even slight differences of colour and size, if found to be constant, are sufficient to constitute such individuals a distinct race or species. When such differences are found to co-exist with a different geographical distribution, I certainly prefer the views of those who look on all permanent distinctions of colour, size, structure, &c., as distinct species; and I believe that no change of climate, or food, or other external circumstances, will produce any alteration in them or in their descendants, if they remain true to each other; and as yet I know of no recorded instance where any well-marked race has produced offspring differing from their own, or tending to revert to a supposed original type. That various nearly-affined species will propagate *inter se*, and produce fertile offspring, I fully believe; as in the cases of the green Pigeons of Bengal and of Southern India, in the Indian and the Burmese Rollers, the small Cuckoos of South India and those of Bengal, and in several other instances: but that this fact militates against their being species and in favour of their being varieties, I think is not supported by many recent experiments in crossing. Of late years many species have been universally admitted as such, which were formerly considered simple varieties, and although, perhaps, the tendency of late writers has been to multiply species, in some cases most unnecessarily, yet in previous years the other extreme was taken, more especially by Schlegel and his followers. Our best naturalists and ornithologists now fully recognize the distinctness of permanent races. If varieties are once allowed, it depends on individual judgment or caprice to what extent they may be carried. In this country, where there are many very closely allied species, among genera characteristic of the country, many of the species of *Malacocercus* and *Hæmatornis* would be classed as simple varieties by some, whilst others would perhaps allow some of them, whose different notes they might have observed, to be distinct species, and the rest varieties. Lastly: it is, I think, more convenient in practice to give each race a distinct specific name, than to speak of them as '*Var. A.*' or '*Var. B.*' of such a species."

With regard to the origin of these allied or "representative" species, as they are usually termed, Dr. Jerdon states that, as far as his "brief experience goes, geographic distribution is against Mr. Darwin's theory. "To give one instance," he continues, "*Malacocercus striatus* of Ceylon is more allied to *M. Bengalensis* of Bengal, than to *M. Malabaricus*, which is spread throughout a vast region between those provinces." On this point we may remark that the great mass of evidence in such cases is, as is now generally allowed, decidedly on the other side of the question. It is beyond a doubt, that allied species, are as a rule, distributed geographically in the order of their affinities, that is, that the most nearly allied occupy conterminous areas. Moreover, Dr. Jerdon ought to be aware that Ceylon, though now-a-days much more nearly connected with the peninsula of India, than with the upper provinces, furnishes many remarkable forms which tend to show that this island has been peopled with life from the other side of the Bay of Bengal, along which the Bengalese species descend, often far to the south. Dr. Jerdon, however, seems to take a very candid view of Mr. Darwin's theory on other points, though he is of opinion that that distinguished naturalist, "perhaps, lays too much stress on external and fortuitous circumstances as producing varieties, and not enough on the inherent power of change."

Dr. Jerdon next proceeds to the difficult subject of the classification of birds, and adopts as his system, nearly that of Mr. George Gray, as given in his 'List of Genera.' Finally, he concludes his introduction with a sketch of the physical features of Northern, Central, and Southern India, in relation to their respective Faunas, and gives some account of what has already been effected by different naturalists who have devoted their attention to various points of the area embraced in these three divisions. The names of Franklin, Tickell, Sykes, and Hodgson are all well known in connection with the earliest researches made in Indian Ornithology. The latter gentleman especially, who was for many years resident at the Court of Nepaul, laboured long and zealously in this, as in other branches of Natural History, and has effected far more than any other naturalist towards making known to us the many singular forms of life that people the slopes of the Himalayas. Other more recent workers in the same field have been Burgess, Adams, Tytler, and McClelland, and last, but not least, Mr. Edward Blyth—for many years the energetic and devoted curator of the Asiatic Society's Museum at Calcutta, whose numerous publications and extensive researches have, as rightly observed by Dr. Jerdon, done more to extend the study of Natural History in India than those of all the previously mentioned observers put together.

We now come to the main portion of Dr. Jerdon's work, which consists of short treatises on each of the species of birds belonging to the Indian Avi-fauna, interspersed with current allusions to the various groups found in other countries, but not represented in the Indian series. Dr. Jerdon's two published volumes treat of the Birds of Prey and the numerous divisions of Insessores or Perchers. Of the first, he gives 81 species as belonging to the Fauna of India, of the Insessores, no less than 689 species are enumerated. Such being the case, it could not be expected that any very detailed account could be given of each bird, especially as what is contemplated is a "brief, but comprehensive Manual." And on the whole, as regards the first volume especially, we cannot but think that we have every reason to be satisfied with the way in which our author has performed his work. The descriptions given are sufficient for the determination of the species in ordinary cases. In many allied forms, it will, of course, be necessary for the student to refer back to the previously published accounts indicated among the synonyms of each species, and in the more difficult cases, to go to the typical specimens in the Museum of Calcutta, or of the British metropolis. The details as regards the geographical distribution, habits, and general alliances of each species are likewise carefully worked out, and the whole account is written in plain and comprehensible terms, well suited for the purpose intended. As an illustration of Dr. Jerdon's style, we extract his remarks on the *Turumti* Falcon (*Hypotriorchis chicquera*)—one of the best known, and commonest small Falcons of India, allied to our Hobby.

"The *Turumti* is universally spread throughout India from north to south, but is rare in the forest districts, as it affects chiefly open country

in the vicinity of cultivation. It frequents gardens, groves of trees, and even large single trees in the open country, whence it sallies forth, sometimes circling aloft, but more generally, especially in the heat of the day, gliding with inconceivable rapidity along some hedgerow, brink of a tank, or across some fields, and pouncing suddenly on some lark, sparrow, or wagtail. It very often hunts in pairs, and I have now and then seen it hover like a kestrel for a few seconds. It preys chiefly on small birds, especially the social larks (*Coryphidea calandrella*), sparrows, and the small ringed-plovers (*Charadrius*); also not unfrequently on bats, which I have seen it seize on the wing just at dusk. It breeds on high trees, and has usually four eggs of a yellowish-brown colour, mottled with brown spots. The young fly early, by the end of March or beginning of April. It has a shrill angry scream, and is very courageous, driving away crows, kites, and even the wokhab (*Aquila fusca*), from the vicinity of its nest or perch. It is occasionally reclaimed, and flown at quail, partridges, mynas, but especially at the Indian Jay or Roller (*Coracias indica*). In pursuit of this quarry the Falcon follows most closely and perseveringly, but is often balked by the extraordinary evolutions of the Roller, who now darts off obliquely, then tumbles down perpendicularly, screaming all the time, and endeavouring to gain the shelter of the nearest tree or grove. But even here he is not safe; the Falcon follows him from branch to branch, drives him out again, and sooner or later the exhausted quarry falls a victim to the ruthless bird of prey. I have known falconers train the *Turumti* to hunt in couples.

"The Indian name, *Turumti*, appears to owe its origin to *Turumtai*, given by Pallas as the Calmuc name of the Hobby.

"A very nearly-allied species of Martin exists in Africa, *F. ruficollis*, Sw. (*chicqueroides*, A. Smith), long considered as the same, but now recognized as distinct by Hartlaub and others. Kaup, P.Z.S. 1851, calls it a sub-species of the other, differing in its darker colours, more striped head, and with the cheek-stripe darker and more distinct."

The second volume of Dr. Jerdon's work is, perhaps, not quite so satisfactory as the first. The descriptions given are mostly shorter and more concise, and we do not find so many of those agreeable episodes upon the habits of the species which tend to render a book of this sort acceptable to the ordinary reader. Yet we must recollect the extent of the subject,—the immense number and variety of the little Passerine birds, of which this part of Dr. Jerdon's book treats,—and how difficult it is to say much when the subject is so new, and when so little, considering the wide field of observation, has been done by former workers. As it is, Dr. Jerdon has already transgressed the bounds originally marked out for himself,—his prospectus having announced the completion of the birds in two volumes. It is perhaps, therefore, hardly fair to find fault with our author on these grounds, though, we think, the Indian field-naturalists, for whose benefit mainly the work was undertaken, will agree with our remarks upon these points.

We have now, in conclusion, one or two criticisms to make upon points which will interest our scientific readers. Dr. Jerdon adopts, as we have already stated, Mr. George Gray's arrangement of the class of birds, and, so far as the six great ordinal divisions (given p. xxxix.) go, we are not aware that he could have much improved upon them. But when he proceeds (p. 151) to employ Mr. Gray's subdivisions of

the great group of *Insessores*, Dr. Jerdon is certainly behind the age. It has long since been most satisfactorily demonstrated that the *Tenuirostres* of Cuvier form a most ill-assorted group, which ought to be divided amongst the others in any natural arrangement, and that, exclusive of the Parrots, there are but three natural sub-groups of Insessorial birds,—namely, the *Fissirostres*, *Scansores*, and typical *Passeres*. We might also object to Dr. Jerdon's collocation of the Swifts and Swallows, to the situation he has assigned to *Upupa*, and to many other minor points. But on the other hand we must congratulate him on his giving the *Megalæmidæ* their true rank as a distinct family, on his correct appreciation of the relation of the Hornbills, and on much that relates to his general arrangement of the smaller groups. On the other hand, Dr. Jerdon goes too fast in another direction, especially when it is recollected that his book is intended for learners and unscientific persons as well as for the initiated. The subdivision of the Genera is carried to by far too great an extent, and this, in our estimation, forms one of the principal defects of the book as a scientific work. The best authorities of the day, in all departments of natural history, set their face against this indiscriminate multiplication of generic terms, which, as carried out by certain writers, bids fair to convert every species into a genus, and renders the burden of recollecting technical names almost insupportable. Generic differences ought to be founded on essential and easily recognizable points of structure. That this is not the plan followed in Dr. Jerdon's book, every naturalist will very soon discover, and we fear the non-naturalists (if we may so express ourselves) will be sorely puzzled in their attempts to fathom many of Dr. Jerdon's minute subdivisions of well-known groups. Who will recognize the Linnæan *Turdi* under the names *Turdulus*, *Planesticus*, and *Geocichla?* Who will appreciate the separation of the well-defined genus of Pipits (*Anthus*) into *Pipastes Corydalla* and *Agrodroma?* In thus following the phantasies of Kaup, and the mad vagaries of Bonaparte (in his latest writings), we cannot believe that Dr. Jerdon has acted well for his own reputation, nor wisely as regards the class of readers for whom his volumes are specially intended.

NATURAL HISTORY ON THE AMAZONS.*

To no class of men are the thoughtful students of Natural History more deeply indebted than to those who, casting behind them all the luxuries and pleasures of civilized life, plunge into the forests and solitudes of far distant regions, there to hold communion with Nature face to face, and to obtain an insight into her workings and modes of action in situations which, under ordinary circumstances, would for

* 'The Naturalist on the River Amazons.' By Henry Walter Bates. 2 vols., 8vo. London: John Murray, 1863.

'Contributions to an Insect Fauna of the Amazon Valley; LEPIDOPTERA, *Heliconidæ*.' By Henry Walter Bates. ('Linnæan Transactions,' vol. xxiii. part 3, page 495.)

ever be concealed from intelligent curiosity. The framers of theories, and the elaborators of grand generalizations, must necessarily own their dependence upon such self-sacrificing investigators, and the value of the facts accumulated by such men depends upon their own inherent powers of observation, and the degree of intelligence and industry they bring to bear upon their self-imposed labours. And seldom indeed does it happen that these qualities are so admirably combined as they appear to be in one whose ardent thirst for natural knowledge impelled him to exile himself for eleven years in a tropical and unhealthy country, in order that he might revel in the rich prodigality of animal and vegetable life which characterizes the great valley of the Amazons—a region which, though far indeed from the comforts and necessities of civilization, may fitly be designated "the Metropolis of Nature."

Mr. Bates embarked at Liverpool in the spring of 1848, in company with Mr. A. R. Wallace, for Pará, the only port of entry to the vast region watered by the Amazons. The object which the travellers proposed to themselves was twofold—to make for themselves collections of specimens, consigning the duplicates to London, to be there disposed of in payment of expenses, *and*, to gather facts towards solving the problem of the "origin of species." The first of these objects was attained in an eminent degree; for not only have Mr. Bates's collections many a time and oft caused congregations of naturalists under the hammer of Mr. Stevens, but he astounds us with the statement of his aggregate results when he informs us, with truthful simplicity, that he obtained, during his eleven years' sojourn, 14,000 insects, and 712 other animals, of which startling total no less than 8,000 were *new to science*. Never has it fallen to the lot of a single individual to bring so vast a contribution to systematic zoology, and it is a grand proof of the rare riches of the teeming district he so wisely selected for his exploration.

With regard to the second object of the journey, while the results have not been so definite as those just glanced at, the two explorers arrived at some conclusions to which we shall refer in the course of the present article, and which, however widely they may differ from the views of another school, will, we venture to predict, be of considerable service in the ultimate advance of science. It is now a matter known to every one, that Mr. Wallace, after spending four years in South America with Mr. Bates, travelled to the East in search of new fields of exploration, and there, while lying stricken down by fever, he elaborated in his busy brain the theory afterwards promulgated by Mr. Darwin in his work on 'The Origin of Species.' It was this fact, and the communication of this hypothesis to Sir C. Lyell, which determined Mr. Darwin to bring his long-cherished views before the Linnæan Society, and thereafter to publish the book which has been so fertile a source of scientific controversy. We may judge, therefore, that as far as Mr. Wallace is concerned, he considered that the facts he had collected threw some light upon the problem which they had charged themselves to illuminate. And in the work before us Mr. Bates proves himself an apt scholar and valuable ally of Mr.

Darwin; and in his preface he tells us that it was Mr. Darwin's opinions and wishes which were mainly instrumental in inducing him to commence the inditing of his book, and the same steady encouragement which strengthened his wavering resolution, and helped him to accomplish the task. We shall not be surprised, then, to find the tendency of the book to be Darwinian.

Mr. Bates made Pará his head-quarters, and his first volume is devoted to that neighbourhood, and his excursions up the Lower Amazons. The zoological richness of the immediate vicinity of Pará itself is something almost beyond belief; and our traveller's account of his first walk on the afternoon of his arrival is most graphic and stirring. Nevertheless he appears to have been at first struck with the generally small size and obscure colouring of the birds, and the similarity of appearance which the insects and birds of the open, sunny places bore to those inhabiting similar spots in Europe. The roadside vegetation consisted of tangled masses of bushes and shrubs, intermingled with prickly mimosas; but, notwithstanding this resemblance to European roadside features, there were, as may be supposed, many others which, at every step, reminded the travellers that they were in another world. The abundance of climbing trees attracted the attention in their first forest walk, and elicited a remark which is extremely interesting, *viz.* that these climbing trees do not form any particular family or genus; there is no order of plants whose especial habit it is to climb; but species of many, and the most diverse families, the bulk of whose members are not climbers, seem to have been driven by circumstances to adopt this habit. The orders Leguminosæ, Guttiferæ, Bignoniaceæ, Moraceæ, and others, furnish the greater number. There is even a climbing species of palm (Desmoncus). This remark is very characteristic of the tendency of Mr. Bates's mind, which, though not to an undue degree speculative, yet sees, in observations like these, something more than the meagre fact which would be patent to all. He concludes the subject with the remark: "The number and variety of climbing trees in the Amazons forests are interesting, taken in connexion with the fact of the very general tendency of the animals also to become climbers." (p. 49.)

The quadrupeds and birds of the forest do not appear to the passing traveller, for, being excessively shy and widely scattered, the first impression which Mr. Bates received was that they were very few; he met with no tumultuous movement or sound of life, but describes it as a solitude, in which only at long intervals animals are seen in abundance, when some particular spot is found which is more attractive than others; and this fact of distribution is one which we have ourselves observed, when, for example, scanning an expanse of sea-shore in search of the smaller marine animals, in situations where certain species are known to abound. The feeling inspired in the Brazilian forests was one of inhospitable wildness, only increased tenfold by the fearful and harrowing uproar made by the howling monkeys morning and evening. Other sounds are not so easily accounted for, even by the natives themselves, such as a sudden noise like the clang of an iron bar against a hard, hollow tree, or a piercing

cry which rends the air—sounds not repeated, while the succeeding silence tends to heighten the impression which they make on the mind. "With the natives it is always the Curipíra—the wild man or spirit of the forest—which produces all noises they are unable to explain." (p. 73.)

Near Cametá, on the river Tocantins, Mr. Bates had an opportunity of verifying a fact which had almost fallen into discredit, *viz.* the bird-catching propensities of the great Mygale spider (M. avicularia). Its web was stretched across a crevice in the tree-trunk, and in it were entangled two birds about the size of our English siskins; one of them was dead, and the other under the spider, not quite dead. The observation appeared to be new to the residents, though the insect was well known; and the *crab-spiders*, as they call them, are injurious even to man, from the maddening irritation produced by their hairs, which come off when touched. Nevertheless, Mr. Bates "saw the children belonging to an Indian family, who collected for me, with one of these monsters secured by a cord round its waist, by which they were leading it about the house as they would a dog." (p. 162.)

The impediments which Mr. Bates encountered in his journeys up and down the 'Great Father of Waters' almost exceed belief, owing partly to the dangers of the river navigation, and partly to the scarcity of trading-canoes large enough for his accommodation. Although but a river, a strong breeze would produce such a *sea*, that the vessel (a schooner) pitched and rolled like a ship in the ocean; and in the Tocantins, the view from the middle of the stream is described as very imposing:—"Towards the north-east, there was a long sweep of horizon, clear of land; and on the south-west, stretched a similar boundless expanse, but varied with islets clothed with fan-leaved palms, visible, however, only as isolated groups of columns, tufted at the top, rising here and there amidst the waste of waters." (I. 220.)

We cannot sufficiently admire the perseverance and earnestness with which Mr. Bates overcame difficulties that would have deterred any ordinary traveller, and encountered dangers of no insignificant nature. These difficulties and dangers are best illustrated by his account of a voyage up the Tapajos, from Santarem to the Mundurucú village. It was necessary first to procure a vessel of his own, a two-masted cuberta, of about six tons' burthen, strongly built of Itauba wood. This was hired at the cheap rate of 1*s.* 2*d.* per diem. Then men were necessary, and although only six were wanted, it was almost impossible to procure them; and at length, after almost fearing that the voyage must be given up, he procured one man, and with his servant José he determined to attempt the journey. Before they had got many miles a storm arose which blew away their boat, tore their sails to rags, snapped their ropes, and drove their vessel broadside on the beach. Nine days were necessary to repair the rigging; but not lost days, for there were rich forests to explore. Having been fortunate enough to meet with another hand, they again proceeded, and for some days all went on well, but the loss of the boat was a great source of annoyance, and ultimately was remedied by building a canoe out of a tree felled for the purpose, and moved with great labour to the river-side upon a

road made for the occasion. The *casca* turned out a success. Add to all this the plagues of *fire-ants*—Tabani, which, by twos and threes at a time, dug their probosces, half-an-inch long and sharp as a needle, through the long thick cotton shirt upon their backs, making them cry out under the infliction, and a host of other inconveniences; and it will be seen that natural-history collecting upon the Amazons is no child's play.

Some curious adventures with serpents rewarded this excursion. On one occasion an Anaconda (Eunectes murinus), 18 feet 9 inches long, was systematically hunted and despatched with harpoons; and he appears to credit reports of similar serpents having been found 42 feet long. Moreover, the natives are not without faith in the existence of a great Amazonian serpent, rivalling the great sea-serpent itself in magnitude. On another occasion, "whilst pinning an insect, I was rather startled by a rushing noise in the vicinity. I looked up to the sky, thinking a squall was coming on, but not a breath of wind stirred in the tree tops. On stepping out of the bushes, I met face to face a huge serpent (Boa Constrictor) coming down a slope, and making the dry twigs crack and fly with his weight as he moved over them. I had very frequently met with a smaller boa, the Cutim boa, and knew from the habits of the family that there was no danger; so I stood my ground. On seeing me, the reptile suddenly turned, and glided at an accelerated pace down the path. Wishing to take a note of his probable size, and the colours and markings of his skin, I set off after him, but he increased his speed, and I was unable to get near enough for the purpose. There was very little of the serpentine movement in his course. The rapidly moving and shining body looked like a stream of brown liquid flowing over the thick bed of falling leaves, rather than a serpent with a skin of varied colours. The huge trunk of an uprooted tree here lay across the road; this he glided over on his undeviating course, and soon after penetrated a dense swampy thicket, where, of course, I did not choose to follow him."

Having stayed about three years and a half at Santarem, and in its neighbourhood, Mr. Bates proceeded to Ega, on the Upper Amazon, or Solimoens, and this distant spot, 1,200 miles from Pará, he made his head-quarters for no less than four-and-a-half years, making during that period, however, excursions of 300 and 400 miles' distance from it. An arduous journey of 35 days from Santarem brought our traveller to Ega, where, far from civilized life, he was often put to great shifts, from the failure of communication and remittances from Europe. From the inhabitants he met with civility and kindness, and although never troubled with impertinent curiosity on their part, his pursuits could not fail to arouse some speculation. The Indians and half-castes complacently thought it but natural that strangers should collect and send abroad the beautiful birds and insects of their country, universally concluding that the butterflies were wanted as patterns for bright-coloured calico prints. We can sympathize with the noble endurance of Mr. Bates, in spite of the difficulty of getting news, the want of intellectual society, and, towards the latter part of his resi-

dence, ill-health arising from bad and insufficient food; and feel rejoiced that he was well repaid by the fact that the neighbourhood yielded him, up to the last day of his residence, an uninterrupted succession of new and curious forms in the different classes of the animal kingdom, but especially insects.

It is difficult, from such a mine of information as is displayed in the contents of these two volumes of travel, to select for illustration one subject of considerably greater interest than another. Mr. Bates discourses of monkeys, of serpents, of birds, of insects, of vegetation, of natives, and all with the air of one who speaks of what he has seen. But it is to insects more especially that his attention was directed, and if we were to single out one subject in particular which he has thoroughly studied, it would be that of the history of the various species of Ants, the Saüba Ant, the Formiga de Fogo or Fire Ants, the Termites, the Foraging Ants, &c., for the graphic and interesting accounts of which, however, we must refer the reader to his volumes. But while it is to insects that he has devoted a large portion of his attention, it is in reference to them also chiefly, that he has advanced those views which we have already alluded to, as bearing upon the question of the origin of species; and in the remaining portion of this article we shall briefly notice those views.

Among insects, the causes and influence of colour is a very important subject, which receives its share of attention, but although the brilliant ornamentation of the males exists in the fauna of all climates, it certainly reaches a higher degree of perfection in the tropics than elsewhere; nevertheless Mr. Bates concludes that it is not wholly the external conditions of light, heat, moisture, and so forth, which determine the general aspect of the animals of a country, and he combats the generally entertained notion that the superior size and beauty of tropical insects and birds are immediately due to the physical conditions of a tropical climate, or are in some way directly connected with them. It is almost always the males only which are beautiful in colours; the brilliant dress is rarely worn by both sexes of the same species. If climate had any direct influence in this matter, why, he asks, have not both sexes felt its effects, and why are the males of genera, living under our gloomy English skies, adorned with bright colours? It is true the tropics have a vastly greater total number of species altogether; the abundance of food, high temperature, absence of seasons of extreme cold and dearth, and the variety of stations, all probably operate in favouring the existence of a greater number and variety of species in tropical than in temperate latitudes; but the contrast between the colouring of the sexes is often greater in the tropics than in any species of temperate zones, so that, in fact, beauty of colour is not peculiar to any one zone, but producible under any climate where a number of species or given genus lead a flourishing existence. These facts "all point to the mutual relations of the species, and especially to those between the sexes, as having far more to do in the matter than climate." Elsewhere he makes a remark in which we most heartily concur: "I think

it is a childish notion, that the beauty of birds, insects, and other creatures is given to please the human eye. Surely rich plumage and song, like all other endowments of species, are given them for their own pleasure and advantage. This, if true, ought to enlarge our ideas of the inner life and mutual relations of our humbler fellow-creatures!"

Again, the similarity of the colour of the insect to the ground it inhabits is an interesting problem touched upon at vol. i. p. 207. This assimilation is exhibited by some and not by others, the dress of some species being in striking contrast to the colours of their dwelling-place. But, as Mr. Bates remarks—The species not so protected "has means of protection of quite a different nature, and therefore does not need the peculiar mode of disguise enjoyed by its companion;" and he properly infers, "that the fact of some species not exhibiting the same adaptation of colours to dwelling-places as their companion species, does not throw doubt on the explanation given of the adaptation, but is rather *confirmatory* of it."

Mr. Bates supports by observation Darwin's views of the competition existing amongst organized beings, and illustrates it in the vegetable world by the growth of the Amazons forest, especially by the *Murderer Liana*, a species of fig, which puts forth arm-like branches from side to side, which meet together, and clasping one another mount upwards, tightly encircling the tree which supports it with inflexible rings, till at length the tree is killed, and "the strange spectacle remains of the selfish parasite, clasping in its arms the lifeless and decaying body of its victim, which had been a help to its own growth. Its ends have been served; it has flowered and fruited, reproduced and disseminated its kind; and now when the dead trunk moulders away, its own end approaches, its support is gone, and itself also falls." Thus the Liana merely exhibits, in a more conspicuous manner than usual, the struggle which necessarily exists amongst vegetable forms in these crowded forests, when individual is competing with individual, and species with species, all striving to reach light and air, in order to unfold their leaves and perfect their organs of fructification. But "there is plenty in tropical nature to counteract any unpleasant impression which the reckless energy of the vegetation might produce. There is the incomparable beauty and variety of the foliage, the vivid colours, the richness and exuberance everywhere displayed, which make, in my opinion, the richest woodland scenery in Northern Europe a sterile desert in comparison. But it is especially the enjoyment of life manifested by individual existences, which compensates for the destruction and pain caused by inevitable competition." (vol. i. p. 56.)

But Mr. Bates's strongest article of alliance with Mr. Darwin is upon the subject of *mimetic resemblances*. This curious topic, touched upon in several places in his work, has received further elucidation in the admirable and elaborate memoir referred to at the head of this article. This memoir was read to the Linnæan Society, Nov. 21st, 1861, and long preceded, therefore, his two volumes of travel, to which we

XUM

have hitherto been referring. By this memoir, entitled 'Contributions to an Insect Fauna, of the Amazon Valley,' Mr. Bates has established for himself a high rank among original investigators, and has shown powers of observation of which he may justly feel proud. For although the subject of recurrent form, or analogical resemblance, or homomorphism, or by whatever title it may be called, has attracted the attention of many naturalists, the manner in which it is here illustrated in the Heliconine group of butterflies, is equally original and acute.

Mr. Bates found that certain butterflies, so closely mocked certain others belonging to distinct groups, that though always on the watch, it required all his caution to distinguish them.* He believes that these resemblances are intended as a protection to otherwise defenceless insects, by deceiving insectivorous animals, and presumes that, seeing the excessive abundance of one species and the fewness of the individuals of the other, that the Heliconide is free from the persecution to which the Leptalis is subjected; and he seems inclined to attribute less to community of habit than we should be disposed to do, though it cannot be denied that such community is a constant concomitant of mimetism.

The bearing of this subject, upon the origin of species, is plainly

* The Heliconidæ appeared to him to be the objects mocked, because they all have the same family facies, whilst the analogous species are dissimilar to their nearest allies,—permitted, as it were, to produce the resemblance from the normal facies of the genus or family to which they severally belong. So close were the resemblances that Mr. Bates was never able to distinguish the *Leptalides* (Pieridæ) from the species they imitated, without close examination after capture. And yet the *Leptalides* belong to a family totally different in structure and metamorphosis from the *Heliconidæ*, which they imitate. Moreover, they fly in the same part of the forest, and generally in company with the species they mimic. Species of Ithomia (*Heliconidæ*) concerned in these imitations have all the character of true species, being distinct and constant. They are all excessively numerous in individuals, swarms of each kind being found in the districts they inhabit. The *Leptalides* are extremely rare; they cannot be more than as one in a thousand of the Ithomiæ. Moreover, none of these *Leptalides* have been found in any other district or country than those inhabited by the Ithomiæ, which they counterfeit. A species very closely allied to L. Lysinoë has been received from Mexico; but an Ithomia of nearly the same colours (I. Nero) also inhabits Mexico. Some other *Leptalides* exist which do not mimic *Ithomiæ*, but some other genera of the same family, as *Methona* and *Mechanitis*. "A similar series of mimetic analogies occurs in the Old World, between the Asiatic and African *Danaidæ* (or representatives of the *Heliconidæ*) and species of other families of butterflies and moths; but no instance is known in these families of a tropical species of one hemisphere counterfeiting a form belonging to the other." So, also, on the banks of the Amazons parasitic bees and two-winged flies mimic the dress of industrious and nest-building bees peculiar to this country, at whose expense they live, in the manner of the cuckoo.

An examination of the beautiful coloured plates in the Linnæan Society's memoir shows that the mimetic resemblances exhibit a minute and palpably intentional likeness, which, as Mr. Bates expresses it, is perfectly staggering; and no wonder, indeed, that he was constantly being deceived by them. Comparing *Leptalis Theonoë* with *Ithomia Flora*, or the *Ega* variety with *Ithomia Illinissa*, *Leptalis Amphione* with *Mechanitis Polymnia* (both var. *Egaensis*), and, again, *Leptalis Orise* with *Methona Psidii*, we cannot fail to be astonished at the closeness of the resemblance, particularly when taken in connection with the normal form of *Leptalis Nehemia*.

stated by Mr. Bates, as a most beautiful proof of the theory of natural selection, by showing that a new adaptation, or the formation of a new species is not effected by a great and sudden change, but by numerous small steps of natural variation and selection. Local conditions favour the increase of one or more varieties in a district at the expense of the others,—the selected ones being different in different districts, in the case of the varieties of *Mechanitis*. "With the mimetic species *Leptalis Theonoe* the case is different. We see here a segregation of local forms similar to that of *Mechanitis Polymnia;* but we believe we know the conditions of life of the species, and find that they vary from one locality to another. The existence of the species, in each locality, is seen to depend on its form and colours, or *dress* being assimilated to those of *Ithomiæ* of the same district, such assimilation being apparently its only means of escaping extermination by insectivorous animals." And indeed the abundance of the mocked species seems to show that it possesses some such immunity, and at all events lives under conditions very favourable to its increase and preservation. To exist in a certain locality, a Leptalis must wear a certain dress, and those of its varieties which do not come up to the mark are rigidly sacrificed.

It is manifestly impossible in a review to enter fully into all the arguments of the work. All that can be done is to indicate the salient points, and abstract the conclusions; and much as these speculations of Mr. Bates have interested us, we must content ourselves with this imperfect *résumé* of them, and refer those who would know more upon the subject to the memoir itself. In taking leave of Mr. Bates, however, we cannot help expressing the gratification and rare pleasure we have felt in the perusal of his 'Naturalist on the Amazons,' in which a vast amount of truthful and original information is given, in an unobtrusive and unselfish style. The world of naturalists is under a heavy obligation to him for his toilsome and laborious collection of facts, and for the interesting, though probably not less laborious, work in which they are permanently embodied. Nor must we omit thanks to Mr. Darwin, for screwing Mr. Bates's courage to the sticking place, without which perhaps the work would never have been written, or at all events have been so deferred as to impair its value. The 'Contributions to Insect Fauna of the Amazons' are an important addition to Entomological science, and however averse some may be to the theory of natural selection, no one can fail to be instructed, as well as interested, by the ingenious remarks with which Mr. Bates preludes the systematic part of the subject. We hail Mr. Bates as a worthy naturalist-traveller, and willingly and gratefully accord to him a well-earned and high position amongst those who have advanced science by patient, earnest, and original investigation.

THE GREAT METEOR OF 1863.*

Amongst the most startling of cosmical phenomena are the occasional appearances of Meteors of extraordinary size and luminosity. Coming without the forewarnings of gathering clouds and dropping rain, their sudden advent in a clear bright sky excites more astonishment in the common observer than the most vivid lightning, while the dull booming sound which follows their disappearance or explosion has more of mystery, and excites more terror than the pealing thunder which succeeds the electric flash.

Almost as transient as—

> "the borealis race
> Which flit ere you can trace their place,"

the scientific observer is often as much at a loss to tell whence they come and whither they go as the ordinary witness of their brilliancy. He is generally but conscious of a momentary flash of light, and on looking to the heavens sees only the trail, something like a luminous scratch in the sky, left by the passing object. A debt of gratitude is therefore due to any philosopher who, like the author of the opuscule we notice, is at the pains to collect and compare the observations of any single example made at widely distant stations, and construct from the whole a connected narrative.

On the evening of the 4th of March, 1863, at about seven o'clock, Dr. Heis, Professor of Astronomy and Mathematics in the Royal Academy of Münster, was taking a walk in the open air. The sky was clear and bright, when suddenly the whole neighbourhood was for a moment lighted up as with Bengal fire, and looking upwards the Doctor saw passing majestically across the firmament a fire-ball which seemed to increase in size until it grew as large as the moon at full. Such an appearance of course excited astonishment in all who witnessed it, and as the author was known to take an especial interest in these phenomena,† a few days brought him numerous communications on the subject. From these, some contributed by astronomers and physicists of great repute, as Baumhauer of Amsterdam, Quetélét of Brussels, and Mr. Greg of Manchester, others from writers of no scientific repute, but as country clergymen telling no doubt truthfully what they believed they saw, and also from the results of his own inquiries among the most stupid of Belgian peasants, the author has drawn up this complete account of the form, apparent size, colour, brightness of the object, as well as the trail, and the manner in which it disappeared or exploded.

* 'Die grosse Feuerkugel, welche am Abende des 4 März, 1863, in Holland, Deutschland, Belgien, und England gesehen worden ist.' Von Dr. Ed. Heis, Professor der Mathematik und Astronomie an der Königl. Akademie zu Munster. Halle: H.W. Schmidt. 1863.

The large fire-ball which was seen in Holland, Germany, Belgium, and England on the evening of the 4th of March, 1863, &c. &c.

† He had published an account of the large Fire Ball seen in Germany on the evening of the 4th December, 1861.

The Meteor appears to have been visible over a hexagonal area, the angles of which are formed by the following places:—Manchester, Brighton, Trêves, Erbach, Hanover, and the North-coast of the kingdom of Hanover. This space encloses more than 100,000 English square miles. The most distant opposite angles in the direction N.W. and S.E. are Manchester and Erbach, 553 miles apart; and from N.E. to S.W. Bremen and Brighton, 401 miles distant.

About the time of the appearance and its duration there is little room for difference of opinion. The author calculates the mean time for Münster at 7h. 6m., and the duration is variously stated to have been from 3 to 6 seconds.

The form and size of the fire-ball are naturally open to wider differences of opinion among the observers, but in this instance the differences are capable of reconciliation. One observer compared the head of the Meteor to the head of a fish, and remarked that it progressed with the movement of a swimming fish. Another compared it to a club, the length of which was three times that of the breadth. The majority observed that it was pear-shaped, egg-shaped, or fig-shaped; hence the author concludes that it was really ellipsoidal. But as most on the Belgian side described it as a "fiery cannon ball," the author infers that the longer axis was directed towards that side.

The apparent size was mostly compared with some terrestrial object. It was said to have been the size of a man's head, a child's head, a hen's egg, or a ball 4, 5, or 6 inches in diameter. Many said it was the size of the moon, others that its diameter was $\frac{1}{4}$, $\frac{1}{3}$, or $\frac{1}{2}$ that of the moon. One observer describes it as four times the size of the evening star, and another says that at its first appearance it was no larger than ordinary star dust (Sternschuppe).

The description of the colour, also, offers some differences. Some say it was of dazzling whiteness, others, a greenish blue, while another remarks that the light resembled that of the Electric spark.*

The colour, however, appears to have been changed by intervening media, so that at some stations it was said to be red, deep yellow, dark red, or violet. The author believes that the real colour of the Meteor was red, inasmuch as it appeared of that colour when at a great height, and in bright moonlight.

The most extraordinary brightness was remarked everywhere; it seemed like the sudden appearance of a full moon in the heavens. Near Boppard, an observer on a mountain saw for a moment the valley of the Rhine lighted up as by a very bright full moon. At one place, a clergyman could distinguish the letters in a newspaper lying on his table, and at Eupen a man could see to read in the street. The shadows of objects were thrown remarkably sharply and well defined; and the confused dance of the shadows of houses and trees, projected as

* The Reviewer, who was passing along Regent Street, London, on the evening in question, was much startled by the sudden appearance of an extraordinary light, which, to him, appeared exactly like the light of the electric spark. On looking to the sky, he saw nothing but a brilliant line of light which appeared to lie nearly East and West, and seemed three or four yards long.

the Meteor darted over the "Domplatz" of Münster, formed a most peculiar sight.

The Meteor was seen through the large western window of the Cathedral of Münster (as is shown in our illustration), by an observer within the building, and this appearance furnished the author, as we shall presently see, with the most important elements from which to determine its height and direction. So near to the earth did it appear at Münster, that people ran to the common before the Castle to find it, thinking it must have fallen on that spot. It was sought for by the peasantry in many places, and in one, as we shall see, by the author himself; and we are by no means astonished to read that at a village near Trêves, the peasants said that a fiery cross had fallen from heaven.

Appearance of the Meteor passing the west window of Münster Cathedral.

As is usually the case, the fire-ball of the 4th of March left behind it a line of light which showed for a few moments the direction it had taken. By some, this is described as a simple straight line of light, and by others, as a trail of sparks. One clergyman, however, denies that it left a trail, and the author accounts for the invisibility by showing that from the geographical position of the observer, the trail must have been covered by the object itself.

The disappearance is variously described by different observers. In most places they agree that the Meteor suddenly appeared and as suddenly disappeared, like lightning. But some assert, that it gave off sparks and burst like a rocket; others say that it burst into small pieces, which seemed to be entirely consumed, while one declares that it disappeared in blackish vapours, which the author does not appear to believe.

In general it has been remarked that the apparent extinction of an object such as that we are describing, has been attended by a noise resembling distant thunder. It has invariably been heard when meteoric stones have subsequently been found. No fragment of the fire-ball of the 4th of March has yet been traced, but it is certain that observers, far and near, say they heard a noise. It was not heard in large towns, even when they lay near to the spot at which the ball disappeared; but that can be easily accounted for. In some places the sound is said to have resembled the rushing noise made by a rocket in its flight, or a passing cannon-ball; in others, it is compared to the dull 'bump' which follows the fall of a heavy body on soft earth. We must remark, that the noise waa heard loudest in North Brabant, and appeared most distant at Hanover, from which important consequences follow.

Respecting the true path of the Meteor, the observations which reached the author left him in no doubt. All the observers in the east saw the object towards the west, going from right to left; while those in the west saw it towards the east, and going from left to right

There were others who supposed it to be going towards the zenith. Two reliable observations further afforded him the means of calculating with some certainty, both the direction and the height. One of these was the observation made in the Münster Cathedral. The large west window of the cathedral was suddenly lighted up, so that the architectural details were all rendered plainly visible, and the observer saw the ball pass across in an oblique direction from the right-hand corner. From measurement of the distance of the observer from the window, and the height of the window, Dr. Heis was enabled to calculate two points in the path of the Meteor.

We may sum up, in a few words, the conclusions at which the author arrived from a careful comparison of the various observations which reached him. He believes that the fire-ball first became visible at a point in the North Sea, about 53° 50′ north latitude, and longitude 5° east of Greenwich, at a height of 88 miles; that it travelled from north to south, and disappeared in latitude 51° 28′, longitude 5° 18′, at a height of 17 miles, having in its visible course traversed 187 miles in 4½ seconds, at the rate of 47½ miles in a second. The path inclined towards the horizon, at an angle of 22°.

We have said that the author himself believed that the fire-ball had fallen to the earth. So convinced was he of this, that he made a journey to the place near which he supposed it to have fallen, in order to search for and make inquiries after it. He wandered over the neighbourhood of Herzogenbusch, in the north of Flanders, for several days, but without success, and departed at last, disappointed indeed, yet still hopeful, for he left at the village schools a promise of a large reward for any boy who should find a meteoric-stone.

On all sides, however, he found the impression existed that the Meteor had fallen in the immediate neigbourhood, and from the interval of time which elapsed between the disappearance of the light and the observation of the sound in this vicinity, he calculated the height at which it exploded. But unfortunately the ideas of the Belgian peasants as to length of the interval were rather vague. Several guessed it at five minutes, which was much too long, so the Doctor, in his perplexity, appealed to an intelligent cook, who both saw the Meteor and was frightened by the noise. In answer to the question, "Could she have boiled an egg hard in the interval?" she replied, "Lord bless me, no—not even soft!—Lord bless me, no; it could not have done in double the time;" and so the interval was reduced from five minutes to less than one minute, which was further diminished by other observers to twenty-two or twenty-five seconds.

If it were solid, and had fallen entire, there would hardly have been much difficulty in finding the object, for Dr. Heis has calculated that in such a case the earth would suddenly have acquired a mountain as large as one of the Siebengebirge. The diameter of the fire-ball he estimates at 1,381 English feet; but it may be, he remarks, that these bodies have only a small nucleus within a luminous envelope.

The cosmical relations of the fire-ball of the 4th of March we must dismiss very briefly. The author determined that it moved around the

sun in a hyperbola, and that it became visible at a point in the heavens near the star γ Cephei. For the elements of this determination we must refer the reader to the little work under review.

With regard to the chemical composition of fire-balls, Dr. Heis has nothing new to tell us. The recent discovery of hydrocarbons, graphite, and free sulphur in stones which have fallen, may lead to the supposition that some are wholly combustible in very attenuated air, and we may thus account for the phenomena of falling or shooting-stars; while in others the mineral matters may predominate, and these sometimes exploding with detonation, fragments fall to the earth constituting meteoric stones.

Respecting the origin and destination of the Meteors and fire-balls we have, of course, no information, and the votaries of modern science and of ancient poetry will still continue variously to regard them as fresh fuel for our flaming sun, or fragments of a shattered world.

MILLS AND MILLWORK.*

To the minds of laymen the vocation of engineering is not so obviously cut up into distinct departments as the better known and older professions. While time and the experience which each of us must encounter teach all men to distinguish, with some approach to accuracy, between the many distinct provinces into which the practice of medicine and that of law are divided, there are comparatively few persons not connected with engineering who are aware that the same division of labour which characterizes each of the three so-called learned professions may be found to regulate and aid the labours of the engineer. The two main lines of the calling are pretty well known under their relative names of Civil, and Mechanical Engineering; but out of these, and especially out of the latter, there spring numerous entirely distinct branch lines, each leading and ministering to its own special industry, and each (to carry out our figure) presided over by a distinct staff of management with widely different functions.

The civil engineers being a more purely professional class than their mechanical brethren, naturally deal with a wide range of matters, and do not greatly tend to split up into specialities; but the mechanician being generally a practical man who lives by producing as well as scheming machinery, soon finds that his business, to be made profitable, must be confined within comparatively narrow limits.

Hence there arises an immense variety of machine makers, all included under the generic title of mechanical engineers, a body amongst whom, taken as a whole, there exists an astonishing amount of practical experience and theoretical knowledge; but each having his own speciality out of which it is seldom his wish or his interest to travel.

This is, however, quite a recent state of things in the profession.

* 'Mills and Millwork.' By W. Fairbairn, Esq., C.E., LL.D., F.R.S., F.G.S., &c. 2 vols. Longmans.

Some fifty years ago, when the machinist's art was in its infancy, the "millwright," who may fairly be considered as the ancestor of mechanical engineers, was far from special in his pursuits. In the best cases he was, to use Mr. Fairbairn's own words, "the sole representative of mechanical art. He was the engineer of the district in which he lived; a kind of Jack-of-all-trades who could with equal facility work at the lathe, the anvil, or the carpenter's bench. Generally he was a fair arithmetician, knew something of geometry, levelling, and mensuration, and, in some cases, possessed a very competent knowledge of practical mathematics. He could calculate the velocities, strength, and power of machines; could draw in plan and section, and could construct buildings, conduits, or water-courses in all the forms and under all the conditions required in his professional practice; he could build bridges, cut canals, and perform a variety of work now done by civil engineers. Such was the character and condition of the men who designed and carried out most of the mechanical work of this country up to the middle and end of the last century."

In the course of the great modern expansion of the mechanical arts, the old millwright has become very nearly extinct, and the wide field in which he laboured has been partitioned among several craftsmen. The domain of mill-work is, however, still very comprehensive, while it is not surpassed in importance by any other branch of mechanical industry.

Mill-work may properly be said to include every engineering process involved in the construction both of the buildings and machinery employed in producing consumable manufactures, including every species of motive power, whether derived from wind, water, or steam. Mr. Fairbairn's book is a practical and, in some particulars, an exhaustive treatise on each of these subjects, which are judiciously divided into five sections, comprising—1. Introduction, with a sketch of the early history of mills. 2. The principles of mechanism. 3. On prime movers. 4. On the machinery of transmission. 5. On the arrangement of mills. Of the two first sections we have little to say; both might have been omitted without detriment to the merits of the work; it is only after we have skimmed the curious information of the first, and glanced at the familiar elementary mechanics of the second section, that we begin to find the great storehouse of the author's original experiences open, or to recognize what an enormous amount and variety of actual practice is here reduced, tabulated, and made ready for the daily use of the millwright and engineer.

Throughout the whole of his work, but especially in the second and latest published volume with which we have more particularly to deal, Mr. Fairbairn is essentially "practical." It is a noteworthy fact that in spite of the aid which mathematical science affords to the engineer, our best machinists and our best machinery are less the result of applied mathematical investigation than of intuitive judgment backed by the time-honoured rule of thumb. It is true that the mathematician's aid is in every-day use in ascertaining the direction and intensity of strains and calculating the resisting powers of the various parts of machinery, but even through all the elaborate tables and rules given

by our author for the determination of the proportions of gearing, shafts, or any other portion of mill work, the fact transpires, that the mathematics have been fitted to the practice, and not the practice to the mathematics. Nor is this peculiar to Mr. Fairbairn; on the contrary, a similar tendency has pervaded the work of our best engineers, so that it has almost come to be believed by some, that a great mathematical capacity is inconsistent with unusual mechanical ability.

Though this is a question of much interest, we do not propose to discuss it here, but merely remark, in passing, that Mr. Fairbairn's work is certainly another and weighty argument put into the mouths of those who hold that the great masters in the mechanical craft have ever used pure mathematics as a very humble kind of servant, treating her mainly as a *custos rerum*, or a means of making the results of their great natural intuition and observation common property for their inferiors or successors.

The second and recently published volume of the work opens with Section 4, and contains an elaborate investigation into the wide subject of the machinery of transmission. Amongst one of the most important general conclusions on this subject, towards which Mr. Fairbairn conducts the reader, is that of the superiority of toothed gearing over straps or other wrapping connectors for purposes of transmission. It is well to have our attention called to this point at a time when the example of American engineers has produced a strong feeling in favour of strapping as compared with gear, and Mr. Fairbairn does good service in pointing out the superiority of wheelwork. The advantages which can be claimed for straps are smoothness of motion, noiselessness of action, and perhaps smallness of first cost; but they are cumbrous, frequently out of repair, destructive in their effects on the journals, and wholly inapplicable in cases where the motion requires to be transmitted in a constant ratio. One of the drawbacks to a freer use of toothed wheels has hitherto been found in the great expense of truly shaped and fitted gears; but the introduction of the wheel-moulding machine, with its consequent improvement in the truth of teeth in cast-wheels, is likely to bring wheelwork into more extensive use than at present.

The chapters on the teeth of wheels would be little more than a recapitulation of the ordinary mathematical demonstration of their true form were it not for the introduction of a most useful series of practical tables, from one or other of which, as if from a ready reckoner, every problem concerning any required wheel may be instantly solved, whether it relate to the strength, pitch, thickness, depth, clearance, or horses' power to be transmitted through a particular tooth.*

* Among the drawings given of various forms of teeth is one which, like the table just referred to, illustrates the very practical nature of this treatise. Our mechanical readers are, of course, aware that in most demonstrations of the Epicycloidal tooth that particular form having its flanks formed by hypocycloids, which are also radial lines, is almost exclusively dealt with. Now this is a tooth which, notwithstanding the simplicity of its delineation, is rarely used in practice, because of its inherent weakness: so, although we get, as usual, some prominence given in the demonstration to the radial hypocycloid, Mr. Fairbairn's practical bent does not permit him to leave his reader without giving a figure of the "teeth of a large wheel, traced from one of my own patterns, to exhibit the form which practice has

The remaining chapters on the machinery of transmission deal chiefly with shafting and its details. Next to the practice of dividing labour into minute departments, and making each man's work a task of repetition, the factory system depends for its economy of production on the concentration of a large number of machines under one building. Some years ago, before this plan was carried to its present extent, it was common in mills to have separate water-wheels to every machine; but, as trade developed, the true principle of concentrating the motive power soon forced itself into notice. No sooner did it become the custom to use either one large water-wheel or steam-engine to drive the whole factory, than the question of shafting for the transmission of power to the distant parts of the building began naturally to receive attention. In order to show to what an extent this system of transmission has been carried, we may mention that, at the great Saltaire Mills, more than two miles of shafting is employed. Nowhere, perhaps, throughout his work, does Mr. Fairbairn give more full, accurate, and useful information in a tabulated form than on the subject of shafting, while the practical examples of couplings, clutches, journals, and brackets, illustrated by detail drawings, comprise every modern design of value.

Section 5, on the arrangement of mills, opens with some very interesting remarks and information on mill architecture. It is true that Mr. Fairbairn does not touch at all upon that frequently agitated question, the shortcomings of the engineer as an architect, but his sketches and observations tend to bring it closely before us. A recent writer very well remarked, in speaking of the relations between the engineer and the architect, that, in consequence of the entirely opposite views which either of the two take of their respective professions, the "architects are quarrelling over Greek mouldings and Gothic pinnacles, and dreaming of *reproducing* the elegance of classical times, while the engineers are spanning our rivers with structures such as the world never saw before, arching under our mountains, and roofing acres for stations. They are, in fact executing a series of works which throw everything else hitherto done into the shade; but all this, unfortunately, without that touch of higher art which is alone wanted for perfection, and this simply because the building profession is divided against itself, because its two branches are conducted on principles so much at variance that they cannot work together. The engineers cannot forego theirs, because they are the only principles which men of sense can follow; so unless the architects will consent to waive some of their archæological fancies, we may be condemned to live in the midst of ugliness for ever. When once this fact is appreciated, we shall surpass all preceding ages in architec-

shown to be desirable." In this specimen, as might have been expected, the flanks of the teeth are generated by a small describing circle, whose hypocycloid gives a tooth admirably proportioned and amply strong in the root. This is a small matter, perhaps, but not an unimportant one. No young student of mechanical engineering is likely to be led astray by Mr. Fairbairn, and the teeth of the wheel, "traced from my own pattern," are a good sample of the principle on which the whole of the book is written.

XUM

ture as we have done in engineering. To call architecture back within the domain of common sense is what is most wanted on the part of the engineers to complete the services they have rendered and are rendering to mankind."

Whether brought about by architects or engineers, there is, however, a great change for the better in the artistic treatment of mill buildings. Mr. Fairbairn gives us a sketch of a very slight attempt at architectural effect with which he succeeded, in 1826, in replacing the old boxlike form of mill, and there is no doubt that much of the credit of modern improvement in this respect is due to him. There is still room, however, for the advent of that architect of the future alluded to by the writer from whom we have quoted above.

Among the most interesting descriptions of mills actually erected by our author which occupy the larger and latter half of his second volume is the Taganrog Corn Mill, on the north shore of the Black Sea, constructed for the Russian Government, and originally intended for the double purpose of supplying the Russian navy with biscuit, and facilitating the export of Russian grain in the shape of flour. The terms of the Paris treaty of peace, stipulating that no vessel of war should be retained on the Black Sea, have modified the original objects contemplated in the erection of these mills, and they are now used only for the purpose of grinding, dressing, &c. The mill contains 36 pairs of stones arranged on Mr. Fairbairn's longitudinal principle, and possesses every requisite for grinding 180 to 200 bushels of wheat per hour.

During the siege of Sebastopol it was determined by the English Government to supply the troops daily with fresh flour from the grain of the surrounding country, and the description of the 'Bruiser' floating mill and bakery is one of the most generally interesting in the book. This vessel was fitted up internally precisely in the same manner as an ordinary mill, the power being derived from her screw engines. Without the sketches it is difficult to extract an intelligible description of the floating mill, but we learn that, "During the time the vessel was in Balaclava harbour, the daily produce of flour was about 24,000 lbs. It was originally intended that the mill should be capable of producing 20,000 lbs. of bread per day, but it proved equal to a considerably larger production. The total quantity of bread turned out in the three months from January to March, 1856, was 1,284,747 lbs., and the expenses of working were 2,017*l.* or 3*s.* 2*d.* per 100 lbs. of bread made. The quantity of flour ground in the same time was 1,331,792 lbs., with 358,172 lbs. of bran; the expenses of working were 2,050*l.*, or 3*s.* 1*d.* per 100 lbs. of flour produced. The total cost of the flour produced was about 25*s.* 3*d.* per 100 lbs., the wheat costing about 18*s.* per 100 lbs. The grinding of the wheat was found to be performed quite satisfactorily while the vessel was at sea, even in a heavy swell causing an excessive motion."

Bearing in mind the success of this experiment and the importance of fresh flour and bread to the health of troops, Mr. Fairbairn suggests the propriety of "a light portable steam-engine and mill for grinding being constantly attached to the camp whenever an

army takes the field. The whole affair would not exceed the weight of one of our heavy siege-guns, and there would be no practical difficulty in the way of introducing an engine capable of supplying newly-baked bread from an oven constructed in the smoke-box of a portable locomotive engine, mounted on wheels and prepared to grind at the same time." Here is another direction in which the ingenuity of mechanicians may be made to serve the interests of military practice, somewhat more peaceable than that which is leading many of our best mechanical engineers to become either artillerists or armour-makers.

Our limits do not permit us to follow Mr. Fairbairn through the descriptions of flax, cotton, oil, gunpowder, and paper mills, all of which are more than usually valuable, as they contain, in almost every case, the story of his own doings, and the result of his own practice. As the most successful and most extensive master-millwright in the world, Mr. Fairbairn has done good service to the profession of engineering by the publication of this work. The subject is one on which there has been a singular dearth of published information; most other important branches of engineering have been treated at length by more or less able authors, but the mysteries of the millwright's craft have been hitherto preserved mainly in oral traditions and empirical rules. No fitter person than Mr. Fairbairn could have been found to give this floating information a shape. Commencing his work as a millwright some fifty years ago, he found the practice of mill-work in a most primitive condition. By the application of new principles, by the concentration of motive power, the substitution of cast-iron wheelwork for the old and cumbrous forms of wooden gear, the improvement of water-wheels by the invention of ventilating buckets, the use of the steam-engine as a prime mover, and last, not least, the introduction of wrought-iron shafting of small diameter, he brought about just such a revolution in the millwright's art as the increasing commercial activity of his time demanded. Like most men who attain celebrity, William Fairbairn has worked hand in hand with circumstances. His professional career commenced, to use his own words, "just at a time when the country was recovering from the effects of a long and disastrous war, and he was enabled, from this circumstance, to grow up with, and follow out conscientiously, nearly the whole of the discoveries, improvements, and changes that have since taken place in mechanical science." Hence it was that he was enabled to apply his great natural mechanical abilities with so much success towards the further development of our industrial resources and the extension of our trade throughout the globe.

XUM

LOCAL FLORAS.*

THE highest attainment of Natural-History science is to describe accurately the living inhabitants of the earth. This can only be done by the slow and laborious process of making catalogues of the plants and animals of particular localities. Such catalogues are of little use to those ignorant of natural-history studies, and can only be compiled by those who have made the greatest progress, and are competent critically to pronounce that the forms alleged to have been found in a particular locality are truly the forms named by some standard authority. It is no wonder then, that so little has been done towards giving an exact account of the animals and plants of any particular district. Of all parts of the world, the British Islands afford the best opportunity for such a study, and perhaps there is no country where so much has been done in this direction. The work is, however, still very imperfect. Our lists of animals and plants, such as are comprehended in our Floras and Faunas, do not pretend to give the localities, excepting generally where any particular species has been found to occur. The relation which a local Flora bears to a general Flora, is well seen in Professor Babington's 'Manual of the British Flora,' and his list of plants in the 'Flora of Cambridgeshire.' In the one, the species of plants are given which occur throughout Great Britain, and the locality is only generally stated by the county or district in which it grows; in the other, every locality in which a particular plant is known to occur, is given.

It is only when plants and animals are studied in the last-mentioned way, that the causes of their growth and distribution can be expected to be discovered. It is evident to all who pass through a limited or large space of country, that the growth of plants is very varied, and no one can fail to be impressed with the fact, that there are certain causes acting which produce this great variety of distribution. A cursory examination shows that such influences as temperature, moisture, water, and composition of soil are at work, and general laws can be laid down according to which certain groups of plants are found to flourish or disappear. It is, however, as we come to examine individual species, that we find no explanation can be given of their absence and abundance; and closer observation of the connection between each species and the soil, and other conditions of their growth, are demanded for the purposes of satisfactorily affording the basis of the laws of their distribution. Much has been done in this direction, and we are indebted to the laborious efforts of Mr. H. C. Watson, to reduce to something like general order what is at present known of the distribution of English plants.

Apart, however, from the scientific interest that attaches to the

* 'Flora of Surrey; or, a Catalogue of the Flowering Plants and Trees found in the County.' By James Alexander Brewer. London: J. Van Voorst.

'Flora of Marlborough; with Notices of the Birds and a Sketch of the Geological Features of the Neighbourhood.' London: J. Van Voorst.

accurate description of plants in particular localities, they have their value in directing the attention of students to places where they can find species which otherwise would escape their attention. It is perhaps to this fact that we are indebted for the publication of local Floras as separate works at all. The publication of such works has been especially called for and produced by the formation of local Naturalists' Field Clubs. These Associations, devoting themselves to the exploration of the natural history of the localities in which they occur, collect a great quantity of information, and it is to such a Society that the public is indebted for one of the Floras named at the commencement of this article.

We are also indebted to other Clubs in various parts of this county for similar works. Nothing can be more conducive to health, both of mind and body, than such Associations, and a public is thus formed capable of appreciating and using Local Floras such as those above mentioned.

It is also very desirable, when the study of Natural History is cultivated in schools and families, that guides to the treasures which are to be found in the immediate neighbourhood should be possessed by the pupils as incentives to the collection of particular or rare kinds of natural-history objects.

It is a mistake to suppose that natural objects can only be successfully studied in their larger or more striking forms; it is the objects which are found at every man's door that become the field for the grandest and most important discoveries. Lyonnet has made for himself an undying reputation by the study of the anatomy of the caterpillar of the common privet hawk moth. Huber studied the bees in his own garden and the immediate neighbourhood of his residence. White has made Selbourne a classical spot for all time by the study of the habits of the animals within a mile of his own house. The finest illustrations of his beautiful theory of the origin of species were derived by Darwin, not from his studies as a naturalist who had voyaged round the world, but as a country gentleman who had studied the habits of the tenements of his dovecote, and the relations of the cats, mice, bees, and clovers in his own paddock. Fascinating as the prospect must be to every young and ardent lover of nature to traverse the ocean, and view its wonders under tropical suns, or pierce the rich forests of the torrid zones, to behold for the first time with human eyes, the forms of animal and vegetable life they may contain, there is nothing more certain than that the fixed and quiet study of natural objects at home can be made as rich a source of intellectual pleasure, and important discovery, as traversing distant, though more fertile fields.

It is with much pleasure, then, that we direct attention to two works which have been recently published on Local Natural History. They are both called 'Floras,' at the same time they are both something more than a mere catalogue of plants and their localities. In both we are supplied with maps of the district, to the elucidation of the botany of which they are devoted. In both we have a sketch of the geology of the part of the country in which the plants are found, a

recognition of the relations of the plants to the soil in which they grow, of considerable importance. To the 'Flora' of Marlborough there is also added a list of birds found in the neighbourhood of that place. We should be glad to see the practice of combining lists of plants and animals followed up so that every student of natural history may be supplied with a knowledge of whatever forms of life exist around him, in whatever direction his particular tastes may lead him.

Of the two works before us the most unpretending is the 'Flora of Marlborough.' It is the production of Mr. T. A. Preston, who is too modest to place his name upon the title-page, but he dates from Marlborough College. He says, in his preface, the work was "undertaken mainly for the purpose of assisting those members of the College who may be fond of Botany." We are sure all friends of a more extended education than is at present afforded in our great educational establishments, will congratulate Marlborough College on the production within its walls of this contribution to Local Natural History. We do not know whether any direct encouragement is given to the study of Natural History at Marlborough, but we regard this publication as one of many other indications that natural science is beginning to excite attention, and its claims to a place in the curriculum of school studies recognized.

In the list of plants presented by Mr. Preston he confines himself to the limit of a circle with a radius of six miles from Marlborough. This circle is divided into four districts, and lies principally upon the chalk formation, so that little opportunity is given for the comparison of plants occurring on different geological strata.

The arrangement of plants followed is that of Professor Babington, in the fourth edition of his 'Manual of British Botany.' The author has done this from the conviction that, although Bentham's 'Hand Book' is extremely useful for those beginning the study of Botany, and has many excellent points about it, yet the wholesale manner in which Bentham has united what have generally been regarded as distinct species, and described them imperfectly, as varieties, have induced him to prefer Babington's book.

The list of plants is preceded by some remarks on the 'Geological Features of Marlborough,' by W. G. Adams, Esq. This essay is devoted to the description of too small a portion of the earth's surface to call for criticism, but it is evidently the production of one who has studied the geology of the district, and contains an interesting exposition of the causes that have been at work in the production of the chalk, and the beds that lie above it in the neighbourhood of Marlborough. We may, however, venture to say that we think the Diatomaceous theory of the production of flints in the chalk, as propounded by Mr. Adams, is hardly borne out by the facts of the case. Whether the silex of flints was once in the form of the skeletons of Diatoms is perhaps a question, but we have no knowledge of any facts which could lead to the conclusion that flints are produced as the result of a conglomeration of the skeletons of Diatoms.

Of the list of plants we have nothing further to say than that it is printed on the plan of Professor Babington's 'Flora of Cambridge,'

and that for every locality given for a plant the initials of the name of the observer are attached.

The list of birds has been drawn up by R. B. Smith, Esq., of Corpus Christi College, Oxford. The notes attached to the name of each bird are interesting, and will be found to make this part of the work much easier reading than the list of plants. It would not perhaps be found impossible in Local Floras to make notes to the plants which might be instructive to the beginner in Botany.

The Flora of Surrey is much the most important volume of the two. It is three times the size of the last; has two valuable coloured maps; embraces the plants of a county; has a history; and has been produced by men not unknown to fame. Who that has studied Natural History the last quarter of a century, is not acquainted with the papers of "Rusticus, of Godalming?" It was the late J. D. Salmon, of Godalming, with a few friends interested in the study of plants, who first resolved, at a meeting held in the town of Guildford, to procure materials for the publication of a Flora of the county of Surrey. Mr. Salmon undertook the task of editing this Flora, and had proceeded to some considerable extent with his task when he died. At the sale of his effects, in the autumn of 1861, all his MSS., and a rich collection of plants which he had formed, were purchased by the Holmesdale Natural History Club, and those materials were placed in the hands of the author of the 'Flora of Reigate,' for publication. No one could be better fitted for the work, and Mr. Brewer has now produced a Flora which, for accuracy and extent, stands unrivalled amongst the Local Floras of Great Britain.

As already stated, this work is accompanied with two maps; on one of them the county is divided into nine divisions, to each of which a letter is attached. Each plant is referred to in the list, as it is found in one or other of these divisions. The second is a geological map, which has been drawn and coloured from one laid down by Mr. Joseph Prestwich. The work opens with an Introduction on the Physical Geography and Botanical Divisions of the county of Surrey, which, we are informed, was written by the late J. D. Salmon. It is an interesting geological and geographical account of the county of Surrey.

The list of plants is very copious, and the arrangement and nomenclature generally adopted are those of the fifth edition of the 'London Catalogue of British Plants.' We should have preferred the plan of following some British Manual, and in this respect we think the plan of the Marlborough Flora the best. The notices of localities are very numerous, and the names of the specimens are at once guarantees of the accuracy of the observations.

The most interesting parts of the volume to the general student will be found in the Appendices, of which there are four. In the first is given a list of plants introduced to the country, and *not* thoroughly naturalized. The second contains a list of plants found on the Thames side, near Wandsworth and Battersea, and which are undoubtedly introduced plants from seed brought to this locality by the presence of a large distillery situated at the waterside. They nevertheless have their interest in showing how plants from distant

counties may be introduced and become naturalized. The third Appendix consists of a table showing the geological distribution of plants in the county. From this table we gather that the number of plants known to occur on all strata is 117. The number confined to the valley alluvium, 7; to the superficial gravels, 19; to the Bagshot sands, 9; to the London clay, 14; to the Reading and Woolwich beds, 2; to the chalk, 55; to the upper greensand and gault, 5; and to the lower greensand, 28. The last Appendix gives the relative proportion of the plants of the United Kingdom to those enumerated in the Surrey Flora, and also the proportion which the number of species in each natural order in Surrey bears to the total amount in the country. From this table we find that Surrey is deficient in the following natural orders:—*Frankeniaceæ*, *Tamariscaceæ*, *Illecebraceæ*, *Plumbaginaceæ*, *Eleeagnaceæ*, *Aristolochiaceæ*, *Empetraceæ*, and *Eriocauloneæ*. It will at once be seen that none of these are common orders.

The Flora of Surrey contains altogether 984 species, besides 65 well-marked varieties. The following five plants are believed to be peculiar to Surrey. *Impatiens fulva*, *Teucrium Botrys*, *Lilium Martagon*, *Digitalis sanguinalis*, and *Buxus sempervirens*. The latter, the common Box, is well known throughout England, but is not thoroughly naturalized in any other county.

From what we have said, it must be seen that the Flora of Surrey is a most valuable and laborious work, and deserves to be in the hands not only of every lover of Natural History in the county of Surrey, but in those of every student of Botany throughout the country. We are glad to observe a good list of subscribers, and wish that our good opinion of the work may be the means of increasing its sale, and encouraging Local Natural History societies to follow the good example of the Holmesdale Natural History Club.

NOTES AND CORRESPONDENCE.

On the Highest Magnifying Power of the Microscope yet employed.

In giving a very brief summary of my recent observations upon the mode of termination of the nerves in voluntary muscle, the editor of 'Cosmos,' for August 28th, 1863, remarks:—"Nous regrettons pour notre compte que M. Beale n'ait pas dit dans sa note avec quel genre d'oculaires et avec quel jeu de lentilles il a pu obtenir le prodigieux grossissement de 3,000 fois."

I propose in the present short communication to describe briefly how my drawings representing objects magnified to this extent were obtained. In making drawings of microscopical objects, it is usual to represent the image the size it appears when thrown upon paper with the aid of the camera or neutral tint glass reflector at the distance of 10 inches from the eye, the arbitrary point at which the magnifying power of object-glasses is measured. If the image be taken at a point nearer to the eye it appears smaller; while, at a greater distance, it of course appears much larger than at the arbitrary distance above stated. Large diagrams may indeed be made *direct from the microscope*, by placing the diagram paper at the distance of 3 feet or more from the eye, and tracing upon it with a long pencil the object as reflected from the neutral tint glass reflector.

In practice, I have often found it almost impossible to represent, in drawings, lines as fine as those seen in the preparation. A certain coarseness is inevitable. The copied lines and markings appear rougher and thicker than the real ones. But this defect is to some extent removed by drawing the object somewhat larger than it appears to be magnified at the distance of 10 inches from the eye; and, in order to obtain uniform results, I always draw the object the size it would appear if copied on the same level as the stage of the microscope. The scale for measurement is copied at precisely the same distance. A glass which at 10 inches is said to magnify 200 diameters will magnify 215, and my high power, which was made for me two years since by Messrs. Powell and Lealand, instead of magnifying about 1,600 diameters, increases the image of the object to 1,800 diameters. By increasing the length of the tube of the microscope between 4 and 5 inches, I obtain an amplification amounting to 3,000 diameters, and the $\frac{1}{1000}$ of an English inch becomes 3 inches in length.

With care in illumination, I have been able to see points in an object magnified with this power which I had failed to observe under a power of 2,000. It seems to me probable that I may succeed in increasing the power to 5,000 diameters; and with this object I am trying different plans, the results of which shall be recorded shortly. The common paraffin lamp gives a very white and good light for working with these high magnifying powers. I have tried the lime light, but have as yet reaped no advantages from its use.

So far I have certainly obtained better results by increasing the length of the tube of the microscope

than by increasing the magnifying power of the eyepiece, which accords with the results of some experiments performed many years ago by Dr. Carpenter. Of course, the practical utility of increasing the magnifying power entirely depends upon the character of the specimen. Into the question of preparing specimens I must not, however, now enter, further than to say that my specimens are immersed in the strongest glycerine that can be procured. I never represent a structure more highly magnified than is necessary to bring out the points; but I find that, with an improved method of preparation, I desire higher magnifying powers; and I am quite certain that great advantages will be reaped when powers far higher than any yet made or thought of shall be brought to bear upon many structures. The question of preparation is scarcely more than a mechanical one, and new and more exact means of preparation will soon follow improvements in the optical part of the microscope.

It should be stated that many specimens of muscular fibre, nerve fibres, nerve cells, &c., have been prepared, so that they can be magnified 3,000 diameters, and points can be made out (as, for example, what appears a single fibre can be resolved into several) which cannot be seen, or, at any rate, have not been observed, by an ordinary magnifying power.

The object-glass I have employed is the first twenty-sixth made for me by Messrs. Powell and Lealand, which is a most excellent working glass. That it defines exceedingly well, and admits plenty of light, is obvious from the fact that it will allow of the tube being increased in length. By a working glass I mean one that can be employed without trouble or difficulty, and does not require any elaborate arrangements with regard to illumination, adjustment, &c. In fact, I use it without even a condenser, employing only the common concave mirror. There is plenty of room for focussing, although, of course, specially thin glass or mica must be employed. I have made and published many drawings of tissues of the higher animals magnified with this glass, and it need scarcely be said, that as it can be brought to bear upon textures of this class (even bone and teeth), thin sections of which are obtained only with great difficulty, it must be readily applicable to other departments of microscopical inquiry.

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Scientific Education and Natural-History Science in the Kingdom of Italy.

GENOA, *Nov.* 18, 1863.

THE state of science and scientific education in Italy at the present moment, when this country is on the point of emergence from political nonentity, and is beginning to feel that it is one of the great powers of Europe, possesses peculiar interest, and may well justify a few remarks in an English journal established to record the progress of science.

Itself the birthplace of many departments of human knowledge, as well as of many of those men who have been most distinguished in science as well as art, Italy still contains, or has only very recently lost, men of European reputation in Physics, in Astronomy, in Geology, in Zoology, and in Botany; and though some of the most eminent of those now living have been diverted from their ordinary pursuits by the pressing claims of political events, and the absolute necessity that all true men should unite in securing the one great object of nationality and unity, there is abundant proof of healthy activity which in due season may be expected to yield great results.

The Universities of Italy have gradually become lowered in general reputation, owing to the extreme facility afforded to very young men to pass examinations and obtain

diplomas. Each seat of education has outbid its fellows in this respect till the result has become very serious, and a great effort is now being made to raise the standard of education throughout the country. The University of Pisa, always among the most celebrated, has especially recommended itself to observation for its efforts in this direction. At first the natural result was to frighten away so many students as to reduce the numbers very greatly; but already it is found that the degree there conferred is much more valuable, and that it is worth while to take the additional trouble to pass. To Professor Matteucci, whose researches in electricity and general physics, are as well known in England as in Italy and France, much of the credit of this is due. M. Matteucci has now left Pisa, and is established at Turin, where he has already occupied for some time the important post of Minister of Public Instruction. It is not unlikely that he may again be appointed, and it would seem that a more fit appointment could not be made.

One of the latest improvements in Public Instruction has been the foundation of a normal school at Pisa, on the footing of the upper normal schools of France, but with the object of securing a really well-informed class of schoolmasters for the education of all classes throughout Italy. Of this establishment, Professor Villari, the able author of the 'Life of Savaronola,' recently translated into English by Mr. L. Horner, is the director, and he is assisted by an excellent staff of professors in all departments. During the last academical year, the number of students was only about 20, but the entries for the year now commencing (November, 1863) are already much more numerous. Several of the students have passed their University examinations with honour, and are admitted to the normal school at the public expense. Others pay a sum of 80 francs (*3l. 4s.*) per month during their residence. All reside in the building, and dine together as in an English college. The system adopted partakes both of the professorial system as carried out in Germany, and of the tutorial system common at Oxford and Cambridge.

The public museums both at Pisa and Florence, are admirable. Both are particularly rich in wax preparations, illustrative of Comparative Anatomy and Botany. The former is also rich in geological specimens. The various minerals and rocks of Tuscany, and the fossils of the Valley of the Arno are especially interesting, not only to the general traveller, but to the technical geologist; for Italy is beyond all other countries in Europe that one in which the phenomena of metamorphism can best be studied. The neighbourhood of Pisa, with the country a little to the south towards Volterra, affords indeed the best key to the very difficult and complicated changes that have affected rocks of almost all kinds within periods of very various duration. In this part of the world, mineral character is no guide to the age of rocks, and fossils, though they exist and have proved extremely valuable in skilful hands, are so exceedingly rare and imperfect, that no traveller however acute, who trusted to his own observation, could hope to do much with them in a rapid journey. The labours of Professor Paolo Savi and Professor Meneghini have greatly tended to simplify and explain the matter, and assisted by the memoir and very admirable maps just prepared for publication by Professor Savi, no one need now waste his time. The memoir in question is, however, published in a volume on the general statistics of the district, and is not altogether accessible.

It is not generally known that this small corner of Italy around Pisa contains a tolerably complete series of formations. There are old palæozic schists greatly altered, but recognizable, overlaid by carboniferous rocks, in which anthracite represents the coal. Over these

altered rocks is a good representation of the trias, and the lower lias is seen in those wonderful beds of statuary and other marble that are so well known and highly esteemed. Above these, are jurassic rocks, and above these again neacomian sandstones, while the chalk is seen in the *Alberese*, a peculiar limestone sometimes approaching marble in colour, but not saccharoidal. Tertiaries of all ages abound in Tuscany, from the lowest nummulitic rocks to the most recent gravels.

Tuscany abounds also in metals. With Elba close at hand, it may be supposed that there is no lack of iron. Copper ore, the purest and most valuable known, is found at Monte Catini, and in one or two other spots. At Monte Catini, the results have for the last 20 years proved as profitable as the deposit is remarkable. The copper ore is found in kidney-shaped lumps of sulphide of copper, mixed irregularly in a paste of soft, moist serpentinous material. The pockets containing the ore are sometimes large, but in the highest degree irregular. The lode is a kind of vein in the altered volcanic rock of Tuscany, called *gabro rosso*, a singular mass of angular and rounded material. Magnesia has played a very important part in all the changes and modifications that have taken place in it. To the presence of magnesia is due, among other things, the beautiful green marble called serpentine, of which there are so many varieties in Tuscany; and although the serpentine rock of the Lizard in Cornwall is of very different appearance and hardness, the presence of the same mineral causes the peculiarities of both.

Lead ore also is found in Tuscany, and deposits of some importance are worked in various places. The lead contains silver. Other metals (mercury among the number) are not wanting, and there seems a prospect of the metalliferous deposits of Italy soon becoming even more worked than in the days of ancient Rome, when its produce exceeded that of any country known at that time.

But the working of the marble quarries must always be one of the most important departments of mineral industry in northern Italy. No one who has not visited Italy can imagine the vast development of this industry. In Genoa—the city of palaces—rightly called the superb, marble of the most beautiful kind and excellent quality, of endless variety in colour and texture, is almost the only material used for construction. Marble staircases, marble balustrades, marble pediments, and marble floors are seen in every hotel, and even in every private house. The churches are marble inside and out, the public buildings are of the same material. In the streets, on the piers, and above all, in the *Campo Santo* or Cemetery, wherever we may go, the marble is displayed in abundance. The same, to some extent, is the case at Milan, at Pisa, and in most of the other cities remarkable for architectural beauty or interesting in history. The geologist in such a country, and under such circumstances, is sure to find abundant matter for inquiry. The marvellous abundance of marble is the result of change or metamorphic action on various beds of limestone. These changes have originated in the volcanic and other igneous causes traceable everywhere in this part of the world. Active volcanoes, in the south extinct, but perfect volcanic craters in the centre, and occasional earthquakes in the north of Italy, are or were the cause of the eruptions of sulphurous and other gases, and of hot aqueous vapours loaded with mineral matter. These are common almost everywhere, and it is these that have converted the limestones into marble, the clays into shales, and the sands into quartzite. Whether we take the veined and coloured marbles where the impurities or foreign ingredients still remain, or the true white and statuary marble where the foreign substances only occupy small vein-

icles, or *madri macchei*, as they are here called, the general history is the same, and metamorphosis is the only cause to which we can reasonably refer.

In other departments of natural history, Italy — especially in the northern and central provinces — is not only rich, but is well represented in the principal museums. It is chiefly, however, in the preparations illustrating the comparative anatomy and physiology, both of animals and vegetables, that the extraordinary accuracy, ingenuity, and patience of the Italians can be best appreciated. These are truly wonderful, and they are quite without rival in Europe. Highly magnified representations of the developement of a plant from the seed, a winged insect from the grub, or a chicken from the egg, are not unknown elsewhere, but at Florence and Pisa there is a profusion of illustrations truly marvellous.

However we may consider the question, we shall find that the recent political changes in this part of the world are already bearing abundant fruit, in the liberation of the human intellect from the slavery that had so long weighed upon it. To say that there are great differences of opinion, and that many persons even regret the old régime, is only to say in another way that the country is free. Everyone may and does safely and loudly express his own view of the government, and all proposed changes are freely discussed. It does not follow that the best measures are at once adopted, but this healthy and free discussion will certainly ensure the greatest ultimate good, while education and science in all departments will not fail in securing their due share of attention when the excitement of politics has a little calmed down. The acuteness of Italian intellect, and the elegance equally characteristic of this people, have still a great part to perform in the history of science.

D. T. Ansted, F.R.S.

Dahomey: its People and Customs.

Whydah, *Sept.* 2, 1863.

Here I am, on my return from Kana, where I was received by the King of Dahomey during the celebration of the "little customs;" and I will now send you some information concerning this country.

Whydah, or Ajudah, is the port of the kingdom, though about two miles distant from the coast. It has 8,000 or 10,000 inhabitants, governed by a "yanogan," who is, in his turn, ruled over by one of the princes of Dahomey. The inhabitants are robust, well formed — I might almost say handsome — with the exception of the head, which wants intelligence: that superior mark which the Creator appears to have denied to the negro race. There is, however, a wide difference between the morals of this people and those further to the south. Nothing is to be seen here calculated to shock the eyes of a civilized man, nor anything objectionable to his ordinary habits. Nay, I can say more; there is positively in the Dahomeyans a sense of personal dignity. Unfortunately, one encounters at every step traces of that Fetischism which arrests all progress, and transforms a man naturally gentle into a brute beast. The principal deities worshipped by this people are — Lightning, or Fire of Heaven; the Boa, or Python; the Lion, the Tiger, and the Vampires.

I visited the Temple of Serpents in this town, where thirty of these monstrous deities were asleep in various attitudes. Each day, at sunset, a priest brings them a certain number of sheep, goats, fowls, &c., which are slaughtered in the temple, and then divided amongst the "gods." Subsequently, during the night, they spread themselves about the town, entering the houses in various quarters in search of further offerings. It is forbidden, under penalty of death, to kill, wound, or even to strike one of these sacred serpents, or any other of the same species; and only the

priests possess the privilege of taking hold of them, for the purpose of reinstating them in the temple should they be found elsewhere.

When a house is struck by lightning, the master is obliged to pay a heavy tribute to the priests of the "Fire of Heaven;" for such an event is always regarded as the denunciation of a great culprit. Should a man be struck by lightning, his body is cut in pieces, and sold by the priests to the populace, who devour this roasted flesh! The dwelling of the dead man is then pillaged and razed to the ground; and the Fetisch worshippers immolate victims on its site, in order to appease the anger of the "Fire of Heaven."

The Vampires may be found on trees in the vicinity of the Temple of Serpents; there they are collected by millions, and after sunset they disperse through the gardens and over the surrounding country.

On leaving Whydah for the interior, the traveller at once observes that the land rises gradually through a succession of upheaved plateaux or downs, which run parallel to the sea from east to west, the surface soil being to a great extent intermixed with small rolled flints.

The utmost elevation which I found between Whydah and Kana was 500 English feet, and that was at a village called Havy (? Havee), about halfway between the two towns. Although Kana is lower than this point, it is quite apparent that further towards the north the land again rises to such a degree, that the capital, Abomey, situated ten miles north-east of Kana, must be elevated to about the same height as Havy. From the information that I have obtained in various quarters concerning the interior, there must be a range of mountains about three days' journey north of Abomey. However, this is a question on which I hope shortly to have ocular evidence.

The King received me cordially; but, in order to reach the palace, I had to pass several scaffolds, bearing the corpses of victims who had been immolated on the previous evening. Some were suspended by the feet, others were upright. During twenty days these horrible spectacles were renewed, with a few decapitations in the interval.

Consul Burton was more fortunate than I, for he only arrived at Kana two or three days before the King departed for the war, and after the conclusion of the sacrifices. It is a difficult matter to predict what Europe may gain from this king and his advisers. I believe, however, that if the abolition of the slave-trade be conceded (the very seat and centre of which is at this place —Whydah), there is a happier future in store for this land.

It is with the view to obtain this concession that I am on the eve of my departure with your brave Commodore Willmot, and we shall soon have a definite reply. If it be favourable, my journey of exploration will be suspended; otherwise, I shall at once proceed northward. The concession of the abolition of the slave-trade in the kingdom of Dahomey is the more to be desired, inasmuch as it would put a stop to the depopulation of a country of undoubted fertility and natural wealth, and which is eminently adapted for the cultivation of cotton.

If the King grants the abolition, he would be all the more ready to encourage the growth of that staple, in order to give employment to his people, who would then no longer be compelled to engage in war for the purpose of making prisoners, to be sold as slaves.

This is a succinct account of my hasty impressions of Dahomey; receive it as such as I am able to communicate.

JULES GERARD.

THE GOLD MEDALLISTS OF THE SCIENCE AND ART DEPARTMENT OF THE COMMITTEE OF COUNCIL ON EDUCATION.

It affords us great pleasure to give publicity to the names of those Students who succeeded in obtaining Gold Medals in Science at the Examination held by the above Department of the State last May in London and the provinces.

GROUP I. *Geometry, Mechanical Drawing, and Building Construction.*

Student's Name.	Age.	School or Residence.	Occupation.	Name of Teacher.
Rowden, William T.	23	*Trade School, Bristol.*	*Science Teacher.*	*Self-taught.*

GROUP. II. *Theoretical and Applied Mechanics.*
No Gold Medal awarded.

GROUP III. *Experimental Physics.*

DOHERTY, JOSHUA	26	180, Agnes-street, Belfast.	National Teacher.	Eardley, F.

GROUP IV. *Chemistry Inorganic and Organic.*

GOOGAN, RICHARD	21	North Main-street, Bandon.	Geologist.	Hofmann, Dr., and Dowling, J.
O'SULLIVAN, CORNELIUS	21	South Main-street, Bandon.	Geologist.	Hofmann, Dr., and Dowling, J.

Note.—Mr. O'Sullivan was *very* nearly equal to Mr. Googan, and having taken the Silver Medal last year he could not receive it again. He has therefore, under the exceptional circumstances, been awarded a Special Prize of Books of the value of 3*l*.

GROUP V. *Geology and Mineralogy.*
No Gold Medal awarded.

GROUP VI. *Animal Physiology and Zoology.*

WILSON, GEORGE	25	12, Stanley-street, Pimlico, London.	Student of Science.	Self-taught.

GROUP VII. *Vegetable Physiology and Systematic Botany.*

WILSON, GEORGE	25	12, Stanley-street, Pimlico, London,	Student of Science.	Self-taught.

GROUP VIII. *Mining and Metallurgy.*
No Gold Medal awarded.

The first-named of these Students (Mr. Rowden) received only a Certificate, as he does not belong to the Classes entitled to receive Medals. The following is the Government Regulation concerning the Medals generally:—"The Queen's Medals which are offered for competition throughout the United Kingdom at the General Examination of Science Schools and Classes held each year in May consist of one Gold Medal for each group of subjects, and one Silver and two Bronze for each subject. All persons wherever taught may compete, the only restriction being that the Medals cannot be taken by Middle Class Students who are more than seventeen years of age. Middle Class Students above seventeen years of age who would otherwise have taken the Medal receive an Honorary Certificate instead."

XUM

Books received for Review.

From *Messrs. Blackwood & Sons*:—

PHYSICAL GEOGRAPHY (Introductory Text-Book of). By David Page, F.R.S.E., F.G.S., &c. 193 pp. 1863.

From *Messrs. John Churchill & Sons*:—

QUALITATIVE CHEMICAL ANALYSIS (A System of Instruction in). By Dr. C. R. Fresenius, Professor of Chemistry, Wiesbaden. Edited by J. Lloyd Bullock, F.C.S. 6th English Edition. 360 pp. Coloured Plate of Spectrum Analysis. 1863.

TOPICS OF THE DAY (Medical, Social, and Scientific). By James Ansley Hingeston, M.R.C.S., L.S.A. 400 pp. 1863.

From *Messrs. Longman & Co.*:—

MANUAL OF THE METALLOIDS. By James Apjohn, M.D., F.R.S., M.R.I.A., Professor of Chemistry in the University of Dublin. 600 pp. 1863. (One of Galbraith & Haughton's Scientific Manuals.)

From *Mr. Lovell Reeve*:—

DICTIONARY OF NATURAL HISTORY TERMS WITH THEIR DERIVATIONS: including the various Orders, Genera, and Species. By David H. McNicoll, M.D., M.R.C.P. 590 pp. 1863.

From *Mr. Van Voorst*:—

FLORA OF MARLBOROUGH, with notices of the Birds, and a sketch of the Geological Features of the Neighbourhood, with a Map. 153 pp.

FLORA OF SURREY; or, a Catalogue of the Flowering Plants and Ferns found in the County, with the Localities of the Rarer Species. From the Manuscripts of the late J. D. Salmon, F.L.S., and from other sources. Compiled for the Holmesdale Natural History Club, Reigate. By James Alexander Brewer. 391 pp.

THE FIRST PRINCIPLES OF NATURAL PHILOSOPHY. By William Thynne Lynn, B.A. Lond., F.R.A.S., of the Royal Observatory, Greenwich. 100 pp.

From *the Editor*:—

THE IBIS. A Magazine of General Ornithology. Edited by P. L. Sclater, M.A., Ph.D., F.R.S., Sec. Z.S., F.L.S., &c., &c. Vol. IV. 1862. 392 pp., with 13 coloured Lithographs. (N. Trübner & Co.)

From *the Authors*:—

OPHTHALMOSCOPIC SURGERY (A Manual of), being a Practical Treatise on the Use of the Ophthalmoscope, &c. By Jabez Hogg, F.L.S, &c., &c. 3rd edition. Numerous Chromo-lithographs. 296 pp. (J. Churchill & Sons.) 1863.

HEAT IN ITS RELATIONS TO WATER AND STEAM. By Charles Wye Williams, A.I.C.E. 2nd edition. 220 pp. (Longman & Co.) 1861.

OBSERVATIONAL ASTRONOMY, and Guide to the Use of the Telescope. By a Clergyman. Edited by J. T. Slugg. 96 pp. (Simpkin & Co.) 1862.

THE STARS AND THE TELESCOPE. By J. T. Slugg. (Simpkin & Co.) 1862.

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MAMMALS OF MADAGASCAR